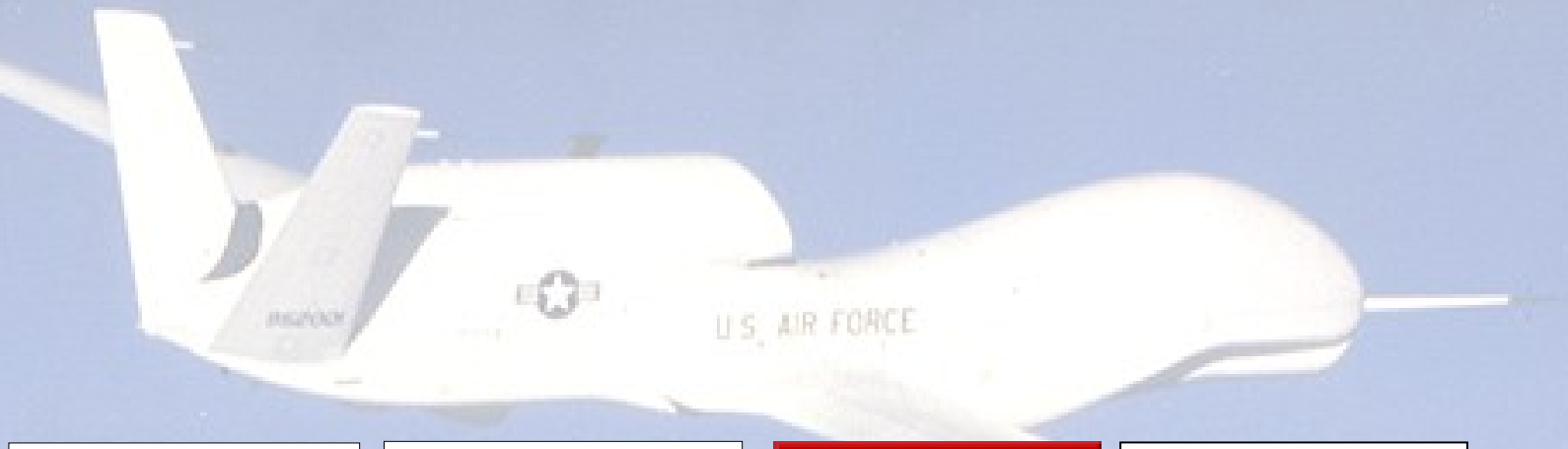
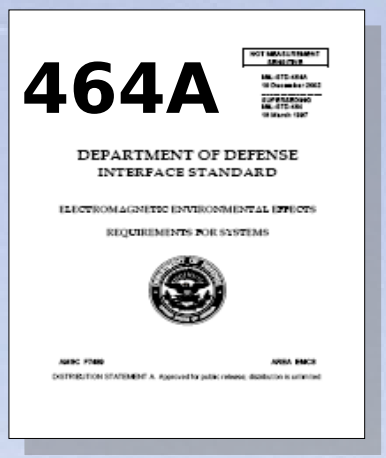
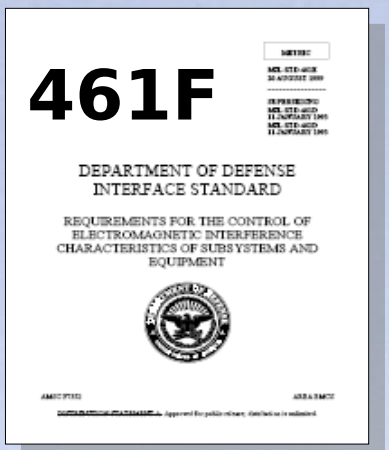
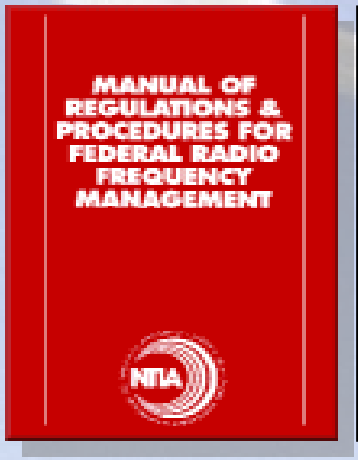
DISA Principle E3/SS Standards





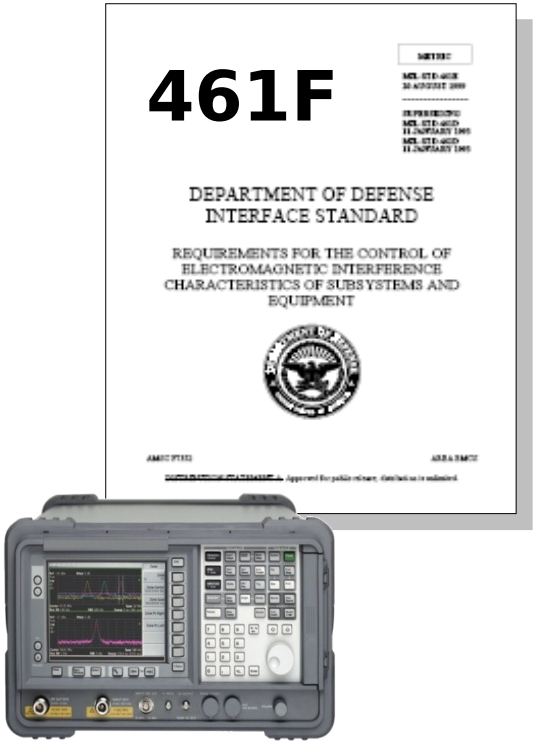

461F
DEPARTMENT OF DEFENSE
INTERFACE STANDARD
REQUIREMENTS FOR THE CONTROL OF ELECTROMAGNETIC INTERFERENCE CHARACTERISTICS OF SUBSYSTEMS AND EQUIPMENT



Performance Specs and Tailoring Requirements

MIL-STD-461F

- **Applies To *Equipment and Subsystems***
- **Conducted and Radiated Emissions, Susceptibility (CE,CS,RE,RS) Requirements, and Test Procedures**
- **Requirements Tailored to Equipment Characteristics and Installation**


461F
DEPARTMENT OF DEFENSE
INTERFACE STANDARD
REQUIREMENTS FOR THE CONTROL OF ELECTROMAGNETIC INTERFERENCE CHARACTERISTICS OF SUBSYSTEMS AND EQUIPMENT

Changes from 461E

- ***Interchangeable Modular Equipment:*** Paragraph 4.2.7 deals with interchangeable modular equipment, and is new in MIL-STD-461F.
- ***Prohibition of Use of Shielded Power Leads:*** ***S***ection 4.3.8.6 ("Construction and arrangement of EUT cables") is more definitive than -461E, stating shielded power conductors may not be used unless the platform shields the power bus from point-of-origin to the load.
- ***Computer Controlled Instrumentation:*** 4.3.10.2 has a title change from "Computer-controlled receivers" in 461E to "Computer-controlled instrumentation", recognizing that more than emissions tests are automated.
- ***Emission Scanning Changes:*** Table II, "Bandwidth and measurement time," which underwent a minor revision from -461D to -461E, is modified to provide an alternative faster sweep speed with multiple sweeps in "max hold" mode.
- ***Susceptibility Scanning Changes:*** Above 1 GHz, the Table III step size has been increased, resulting in a much faster RS103 test in that frequency range.
- ***CE101:*** ***N***ow applicable for equipment used on surface ships.

Changes from 461E

- ***CS106, A New Requirement:*** 461F includes a Navy ships-only "CS106" requirement that is superficially similar to the obsolete MIL-STD-461A/B/C CS06.
- ***CS109:*** ***N***ow only applicable for surface ship equipments that have an operating frequency of 100 kHz or less and have the sensitivity to read a signal at or below 1 µV.
- ***CS114:*** For Navy ships and submarines, there is a low frequency add-on to this requirement that models common mode noise generated by new power systems.
- ***CS115:*** Only applicable for submarine and surface ship procurements when specified by the Procuring Activity. This change fits with the addition of CS106.
- ***CS116:*** There were previously two CS116 limits.

Changes from 461E

- ***RE102***
  - A universal change is in the use of the 41" rod antenna, used below 30 MHz;
  - Figure RE102-6 is revised to show the antenna lowered so that the center point of the 41" rod element is 120 cm above the test chamber floor. Further, this figure shows that the coaxial cable emanating from the rod antenna base is carried directly to the floor and grounded there, with a ferrite bead installed between the rod base and the floor ground point. The ferrite bead should have between 20 – 30 Ohms impedance at 20 MHz..
  - If a rod antenna is used with a coax output connector shell that is isolated from the case, this isolation should be defeated by grounding it to the case.
- ***RE103:*** The requirement is now met if the harmonics do not exceed the applicable RE102 limit.
- ***RS101:*** RS101 for submarine procurements now applies only to equipment and subsystems that have an operating frequency of 100 kHz or less and have the sensitivity to read a signal at or below 1 µV.
- ***RS103:*** In paragraph5.20.3.4.d.1.c. It states: "Ensure that the E-field sensor is indicating the field from the fundamental frequency and not from the

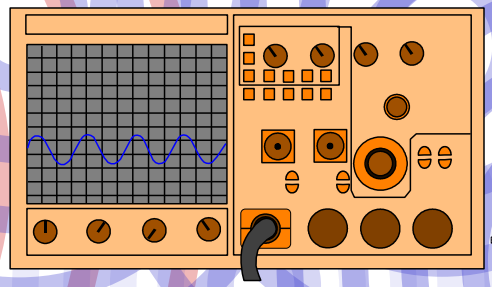
Electromagnetic Interference Emanations to and From Equipment

RE and RS

Radiation into and out of Seams and Apertures

RE

Radiation from Panel Components



CS

Power line conduction

Power line radiation

RE

Interface cable radiation and entry (conduction)

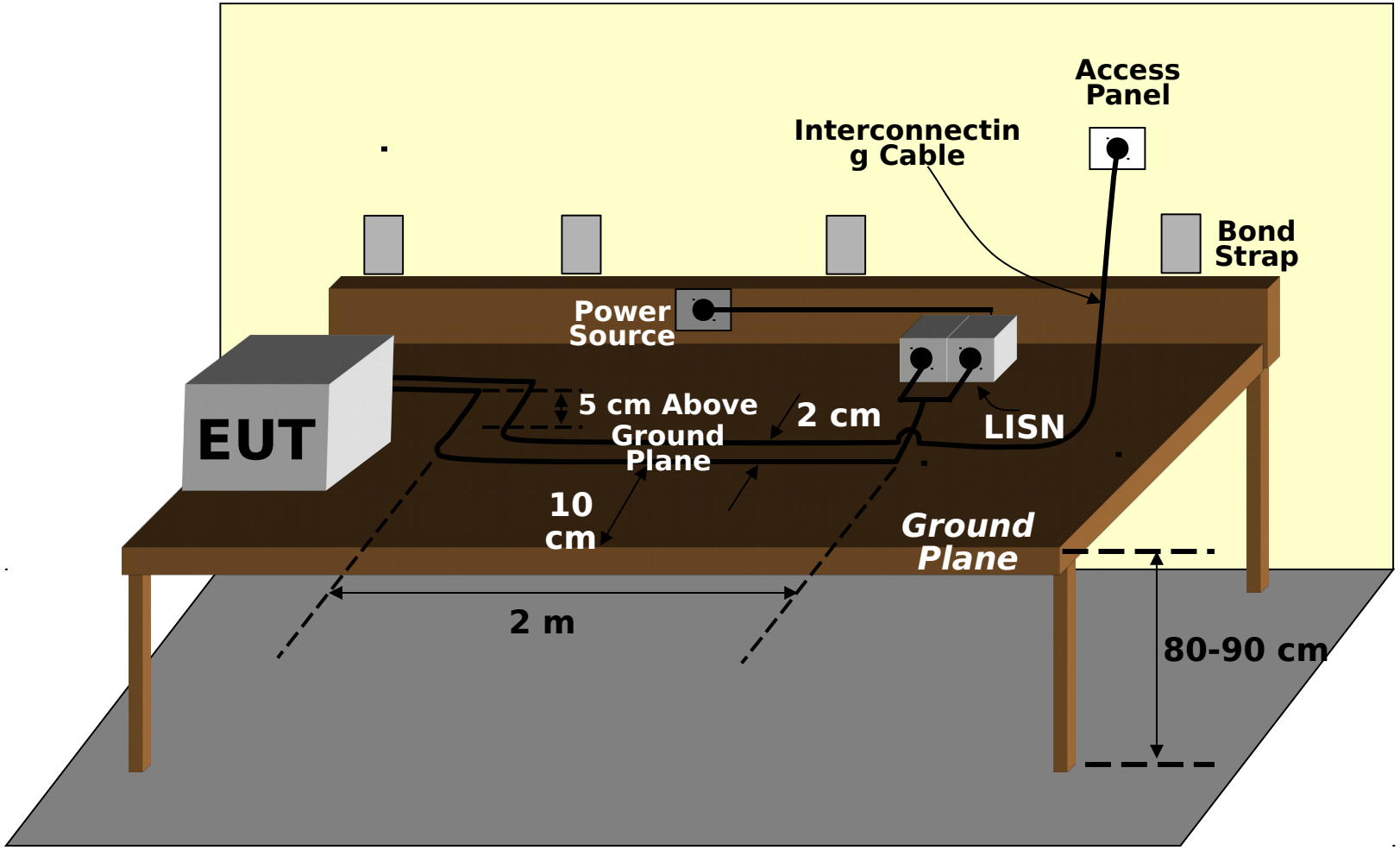
CE and RS/CS

Requirement Matrix
Table V

Equipment and Subsystems Installed In, On, or Launched From the Following Platforms or Installations	Requirement Applicability																	
	CE101	CE102	CE106	CS101	CS103	CS104	CS105	CS106	CS109	CS114	CS115	CS116	RE101	RE102	RE103	RS101	RS103	RS105
Surface Ships	A	A	L	A	S	S	S	A	L	A	S	A	A	A	L	A	A	L
Submarines	A	A	L	A	S	S	S	A	L	A	S	L	A	A	L	L	A	L
Aircraft, Army, Including Flight Line	A	A	L	A	S	S	S			A	A	A	A	A	L	A	A	L
Aircraft, Navy	L	A	L	A	S	S	S			A	A	A	L	A	L	L	A	L
Aircraft, Air Force		A	L	A	S	S	S			A	A	A		A	L		A	
Space Systems, Including Launch Vehicles		A	L	A	S	S	S			A	A	A		A	L		A	
Ground, Army		A	L	A	S	S	S			A	A	A		A	L	L	A	
Ground, Navy		A	L	A	S	S	S			A	A	A		A	L	A	A	L
Ground, Air Force		A	L	A	S	S	S			A	A	A		A	L		A	

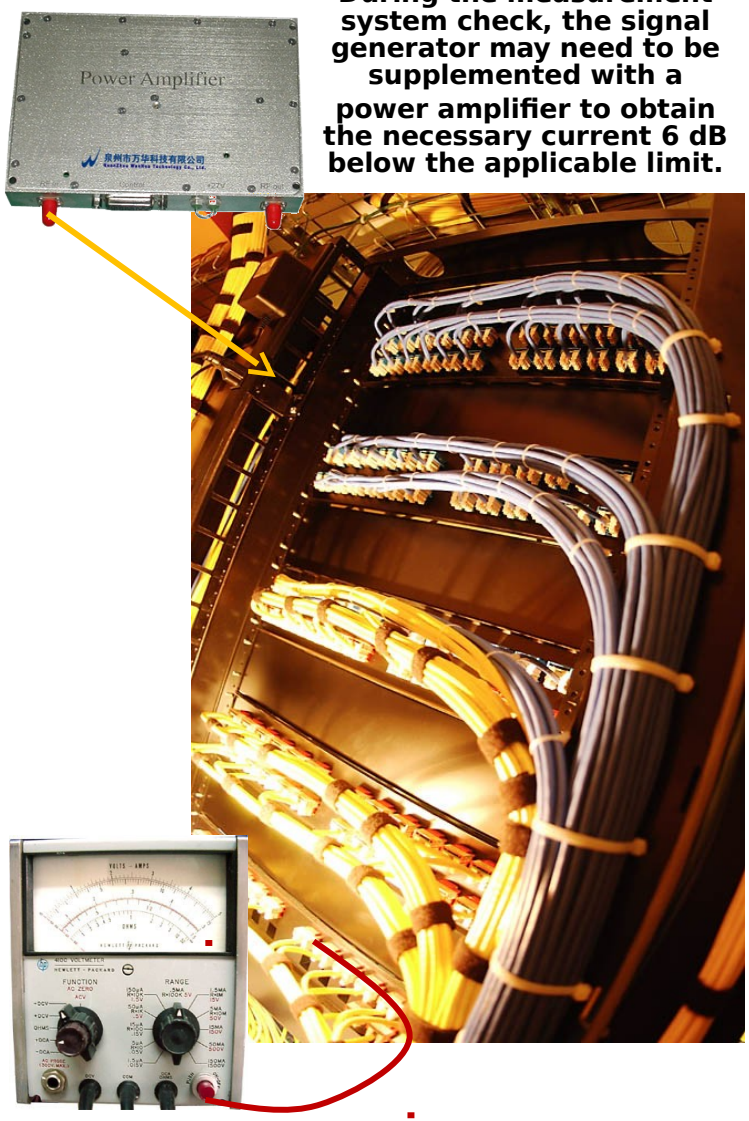
A
L
S

MIL-STD-461F General Test Configuration



5.4. CE101, Conducted Emissions, Power Leads, 30 Hz to 10 kHz

- Applicable to leads that obtain power from sources that are not part of the EUT. There is no requirement on output leads from power sources.
- Emission levels are determined by measuring the current present on each power lead.
- For surface ships and submarines, the intent is to control the effects of conducted emissions peculiar to the shipboard power distribution system
- For Army aircraft, the concern is to ensure that the EUT does not corrupt the power quality on platform power buses
- Navy aircraft applicable for installations using anti-



During the measurement system check, the signal generator may need to be supplemented with a power amplifier to obtain the necessary current 6 dB below the applicable limit.

Figure CE101-1 CE101 Limit For Submarine Applications, DC.

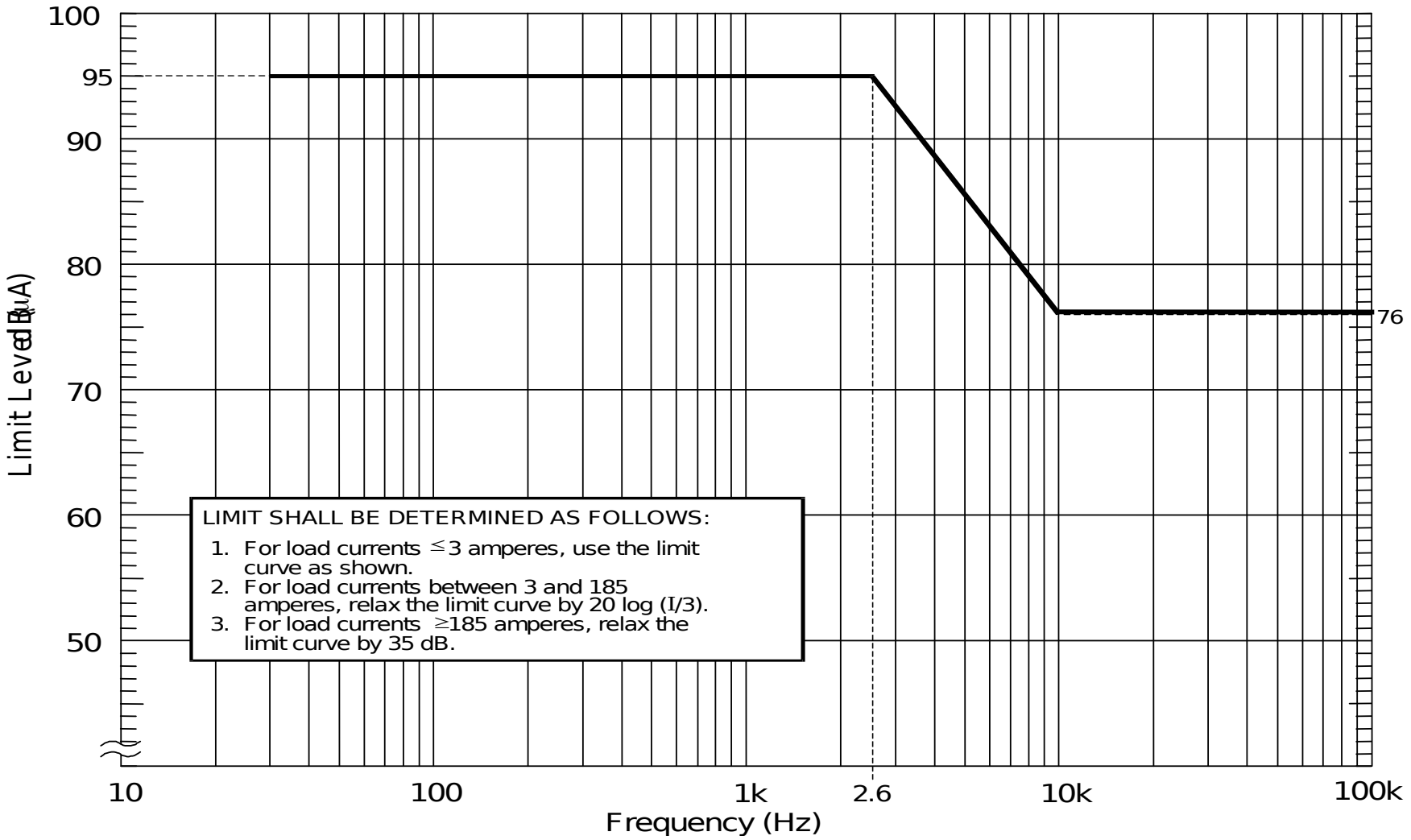


Figure CE101-2 CE101 Limit For Submarine Applications, 60 Hz

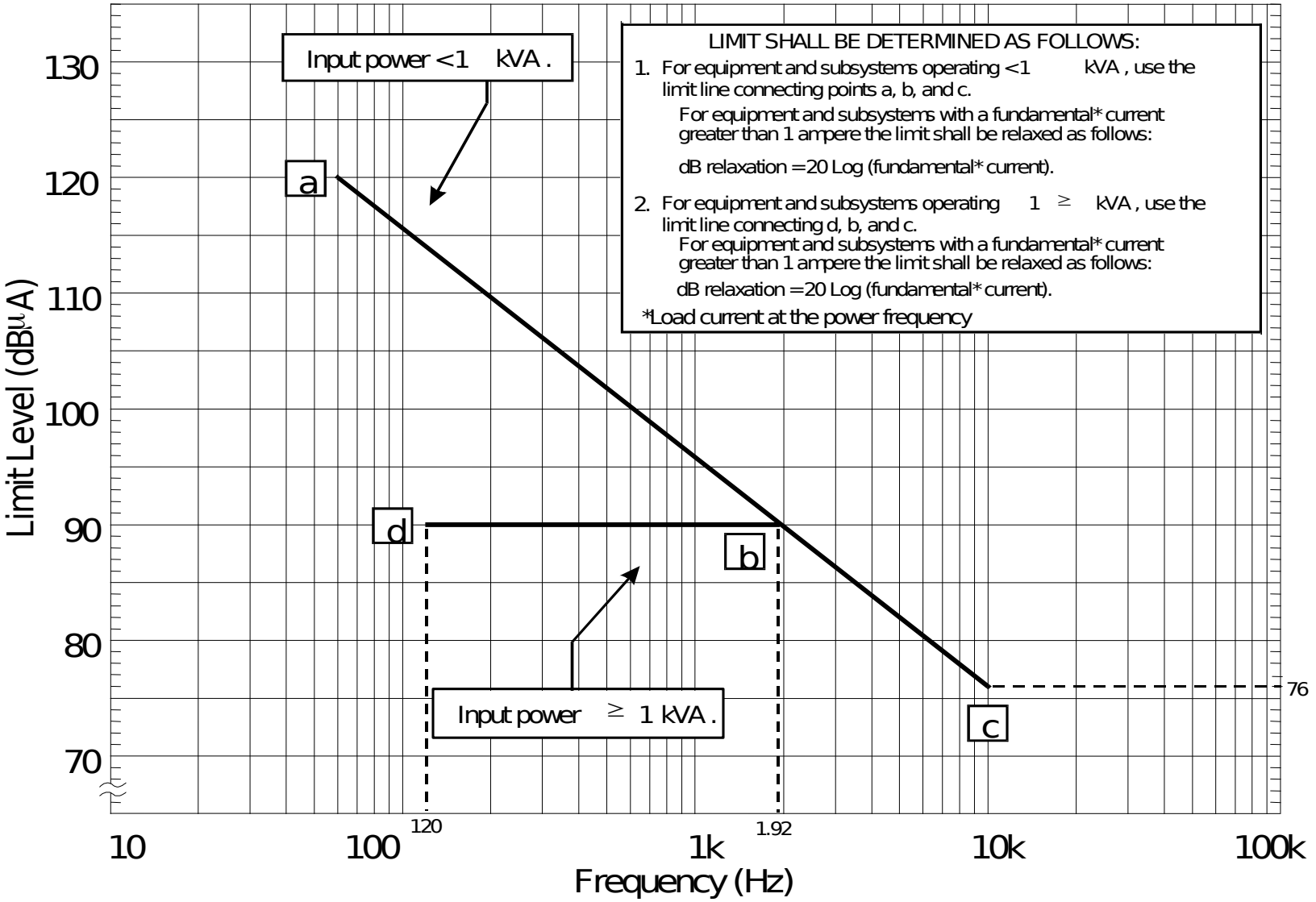

LIMIT SHALL BE DETERMINED AS FOLLOWS:
1. For equipment and subsystems operating <1 kVA , use the limit line connecting points a, b, and c.
For equipment and subsystems with a fundamental* current greater than 1 ampere the limit shall be relaxed as follows:
dB relaxation =20 Log (fundamental* current).
2. For equipment and subsystems operating 1 ≥ kVA , use the limit line connecting d, b, and c.
For equipment and subsystems with a fundamental* current greater than 1 ampere the limit shall be relaxed as follows:
dB relaxation =20 Log (fundamental* current).
*Load current at the power frequency
Input power <1 kVA .
Input power ≥ 1 kVA .
a
b
c
d
130
120
110
100
90
80
70
Limit Level (dBμA)
10
100
120
1k
1.92
10k
100k
76
Frequency (Hz)

Figure CE101-3 CE101 Limit For Submarine Applications, 400 Hz

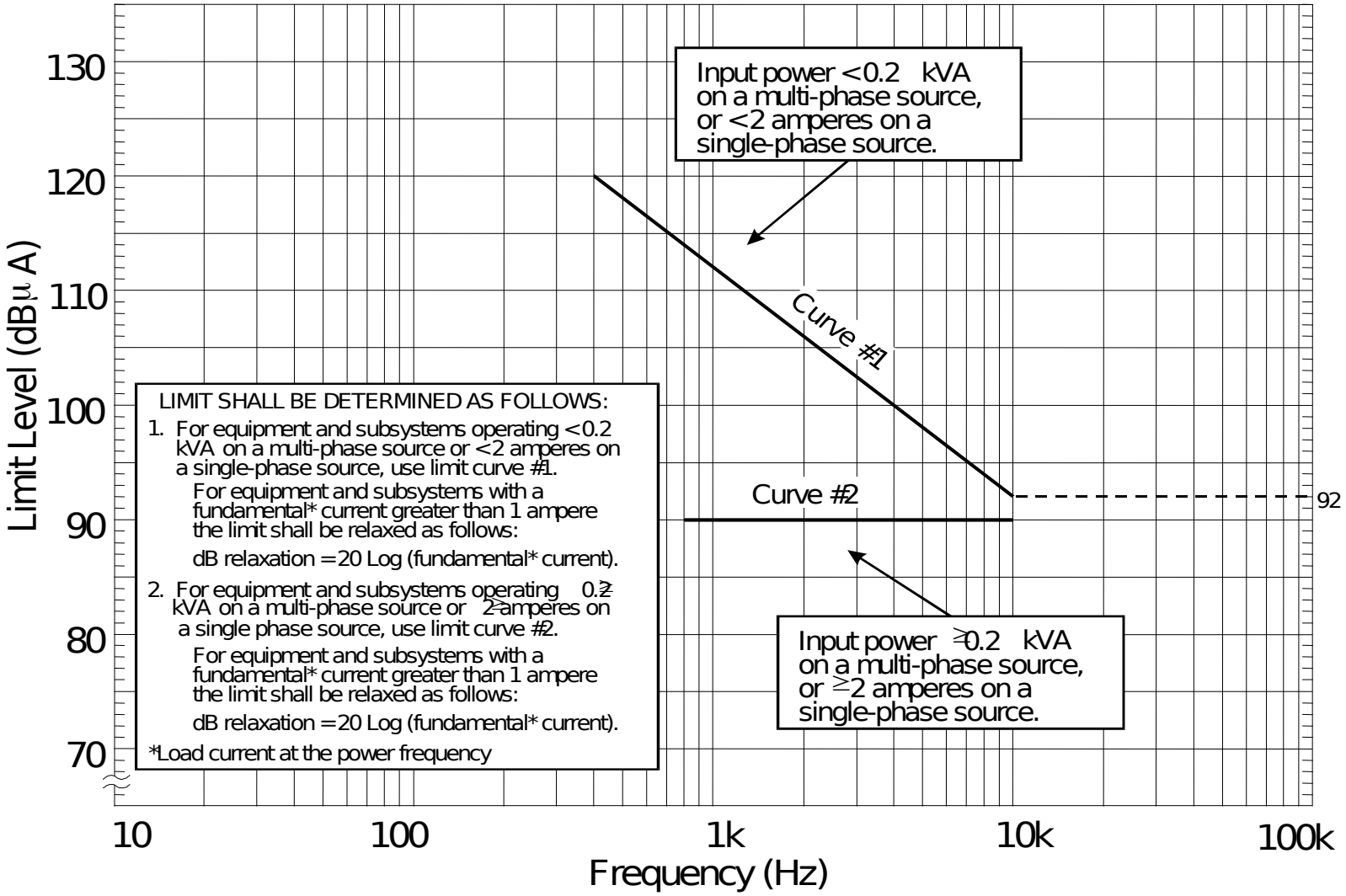
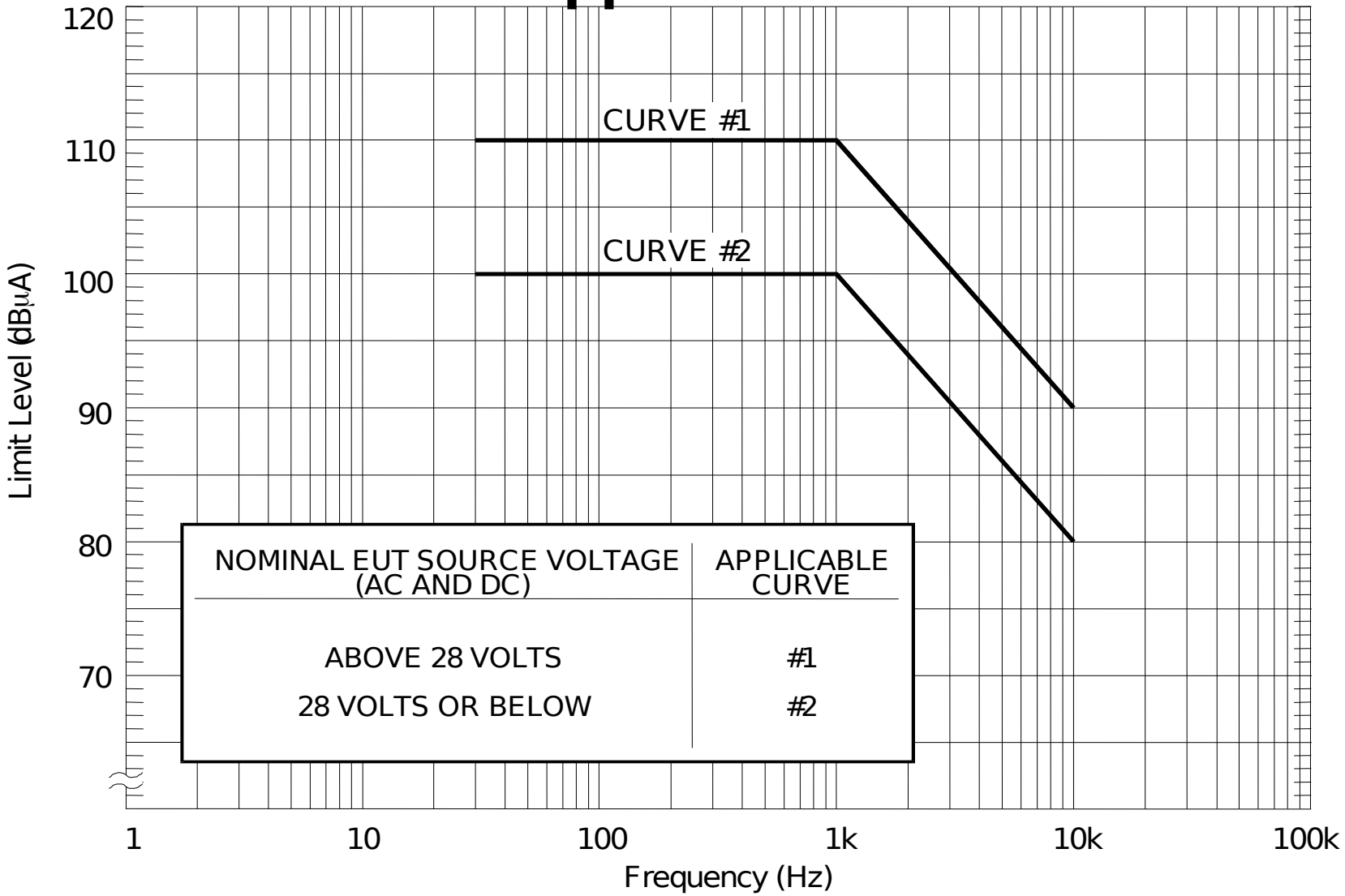

Limit Level (dBμA)
130
120
110
100
90
80
70
10
100
1k
10k
100k
Frequency (Hz)
Input power <0.2 kVA on a multi-phase source, or <2 amperes on a single-phase source.
Curve #1
Curve #2
92
Input power ≥0.2 kVA on a multi-phase source, or ≥2 amperes on a single-phase source.
LIMIT SHALL BE DETERMINED AS FOLLOWS:
1. For equipment and subsystems operating <0.2 kVA on a multi-phase source or <2 amperes on a single-phase source, use limit curve #1.
For equipment and subsystems with a fundamental* current greater than 1 ampere the limit shall be relaxed as follows:
dB relaxation =20 Log (fundamental* current).
2. For equipment and subsystems operating ≥0.2 kVA on a multi-phase source or ≥2 amperes on a single phase source, use limit curve #2.
For equipment and subsystems with a fundamental* current greater than 1 ampere the limit shall be relaxed as follows:
dB relaxation =20 Log (fundamental* current).
*Load current at the power frequency

Figure CE101- 4 CE101 Limit For Navy ASW Aircraft And Army Aircraft (Including Flight Line) Applications



5.5. CE102, Conducted Emissions, Power Leads, 10 kHz to 10 MHz

- Lower frequency portion is to ensure EUT does not corrupt the power quality (allowable voltage distortion) on platform power buses
- Voltage distortion is the basis for power quality so CE102 limit is in terms of voltage.
- Emission levels determined by measuring voltage present at the output port of the LISN

Emission levels are determined by measuring the voltage present at the output port on the LISN

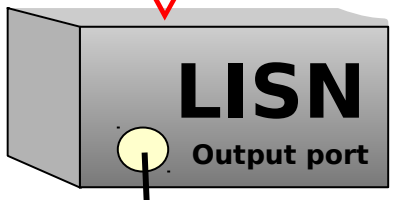
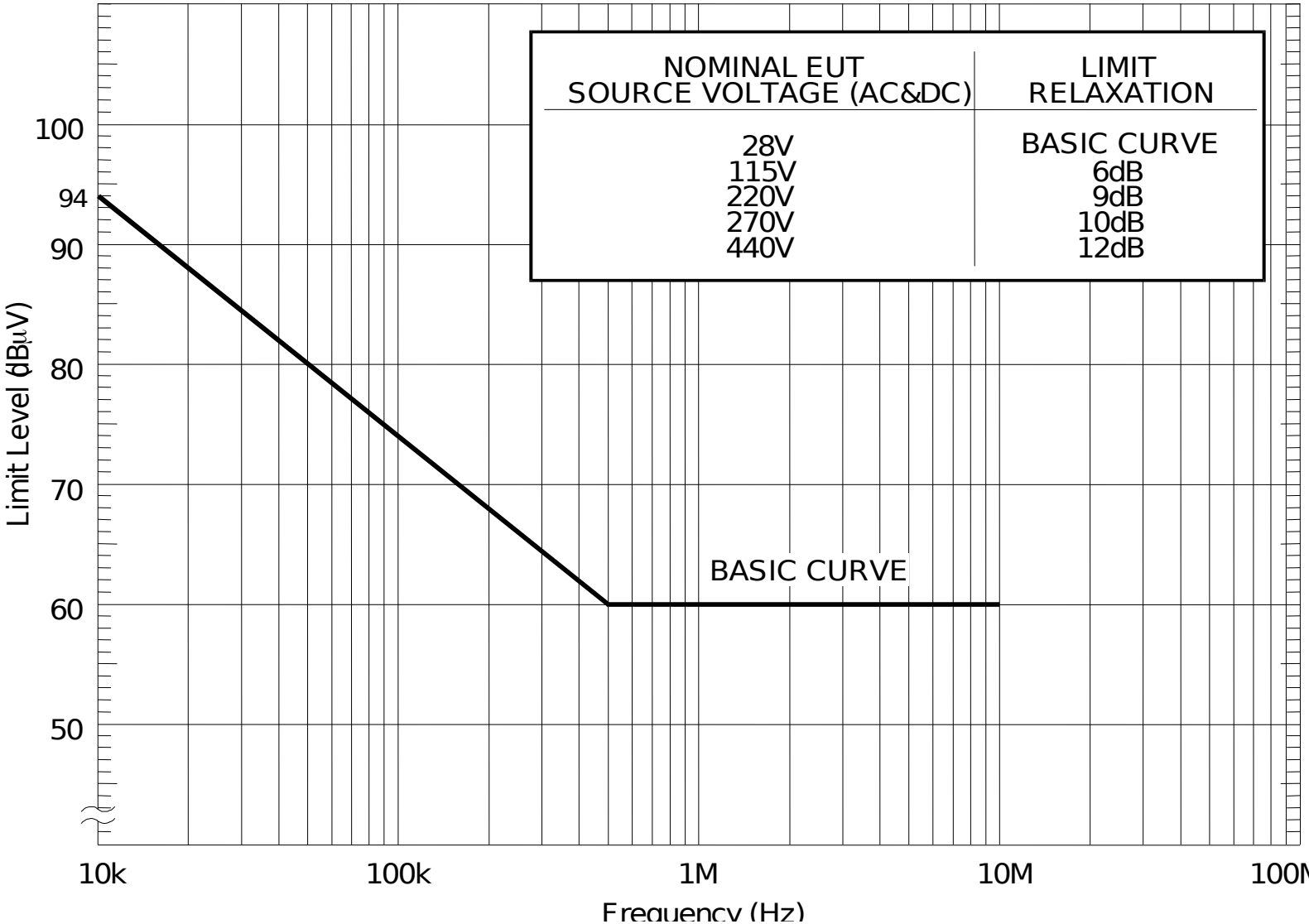
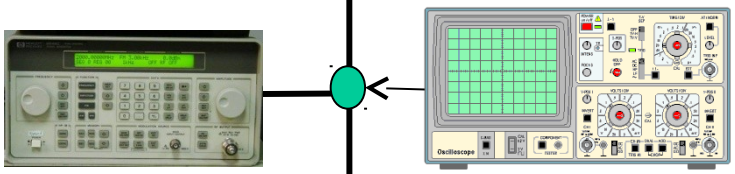


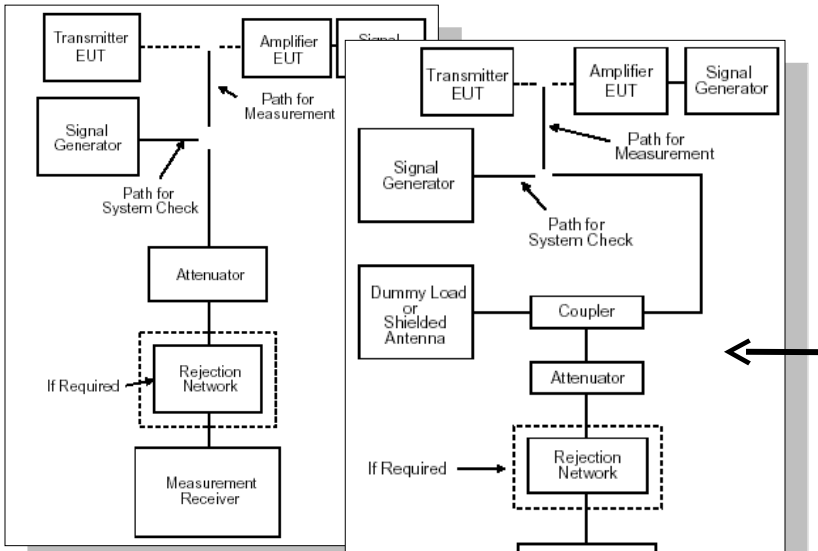
Figure CE102-1 CE102 Limit (EUT Power Leads, AC and DC) For All Applications



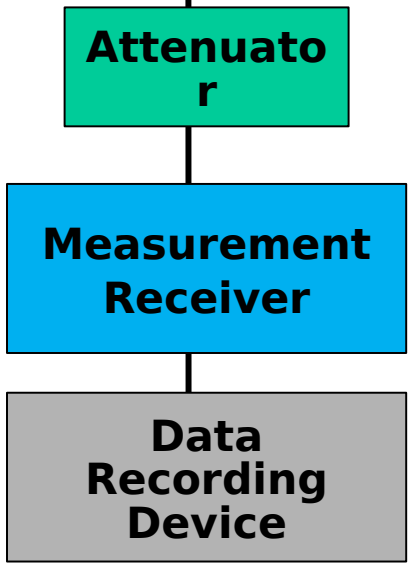
5.6. CE106, Conducted Emissions, Antenna Terminal, 10 kHz to 40 GHz

- CE106 is applicable to the antenna terminals of transmitters, receivers, and amplifiers
- Intent is to protect receivers on and off the platform from being degraded by antenna radiation from the EUT.
- Suppression to meet requirements can be severe resulting in significant design penalties.
- The limits may be tailored by establishing levels based on platform coupling studies



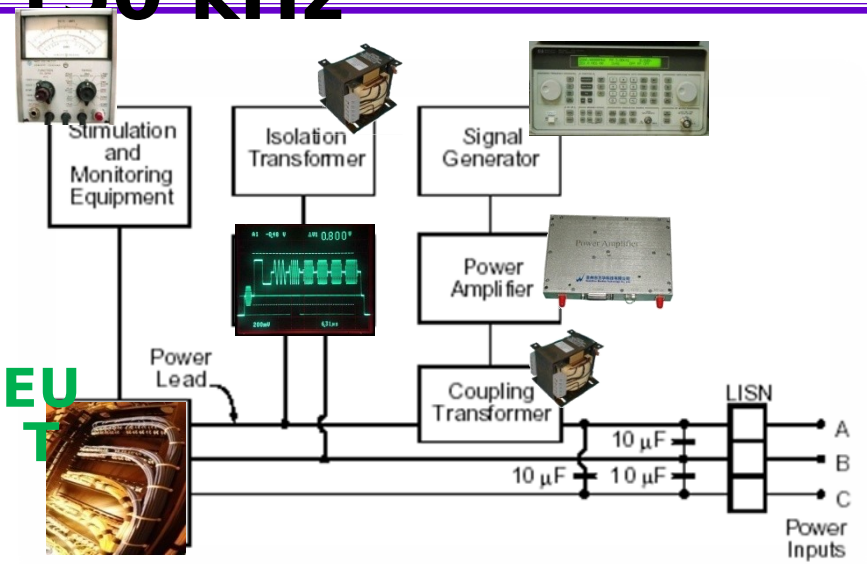


Setup for Receivers and Transmitters in Stand-by Mode. Note: There are other test setups for low power and high average

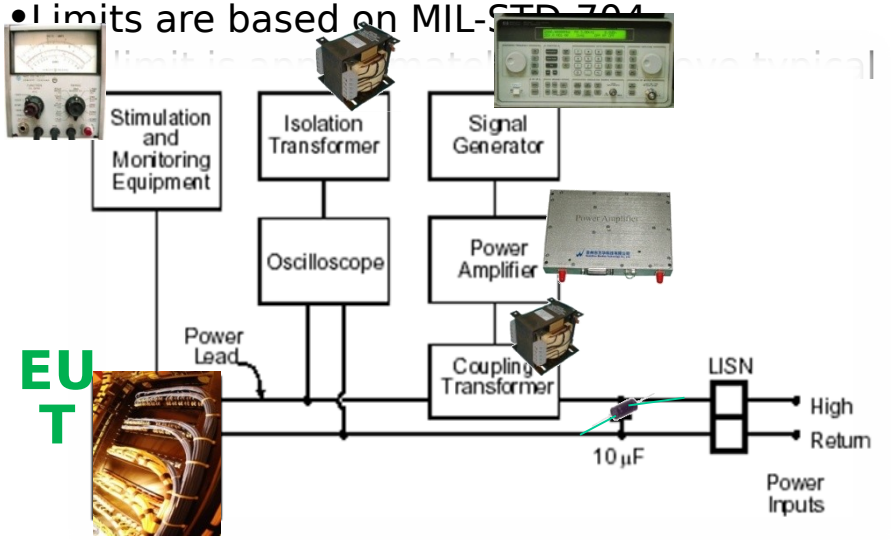


5.7. CS101, Conducted Susceptibility, Power Lead, 30 kHz to 150 kHz

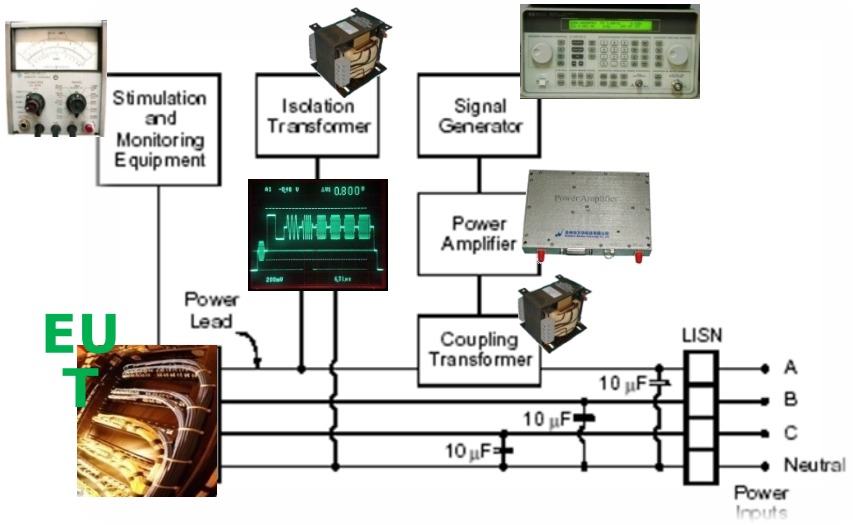
- Applicable to equipment and subsystem AC, limited to current draws ≤100 amperes per phase, and DC input power leads, not including returns.
  - If the EUT is DC operated, requirement applicable over freq range 30 Hz to 150 kHz.
  - If the EUT is AC operated, requirement is applicable from the second harmonic of the EUT power freq and extending to 150 kHz
- Ensures that performance is not degraded from ripple voltages on power source waveforms
- Limits are based on MIL-STD-704



Signal Injection – Three Phase Ungrounded



Signal Injection – DC or Single-Phase AC



Signal Injection – Three Phase Wye

Figure CS101-1. CS101 Voltage Limit For All Applications

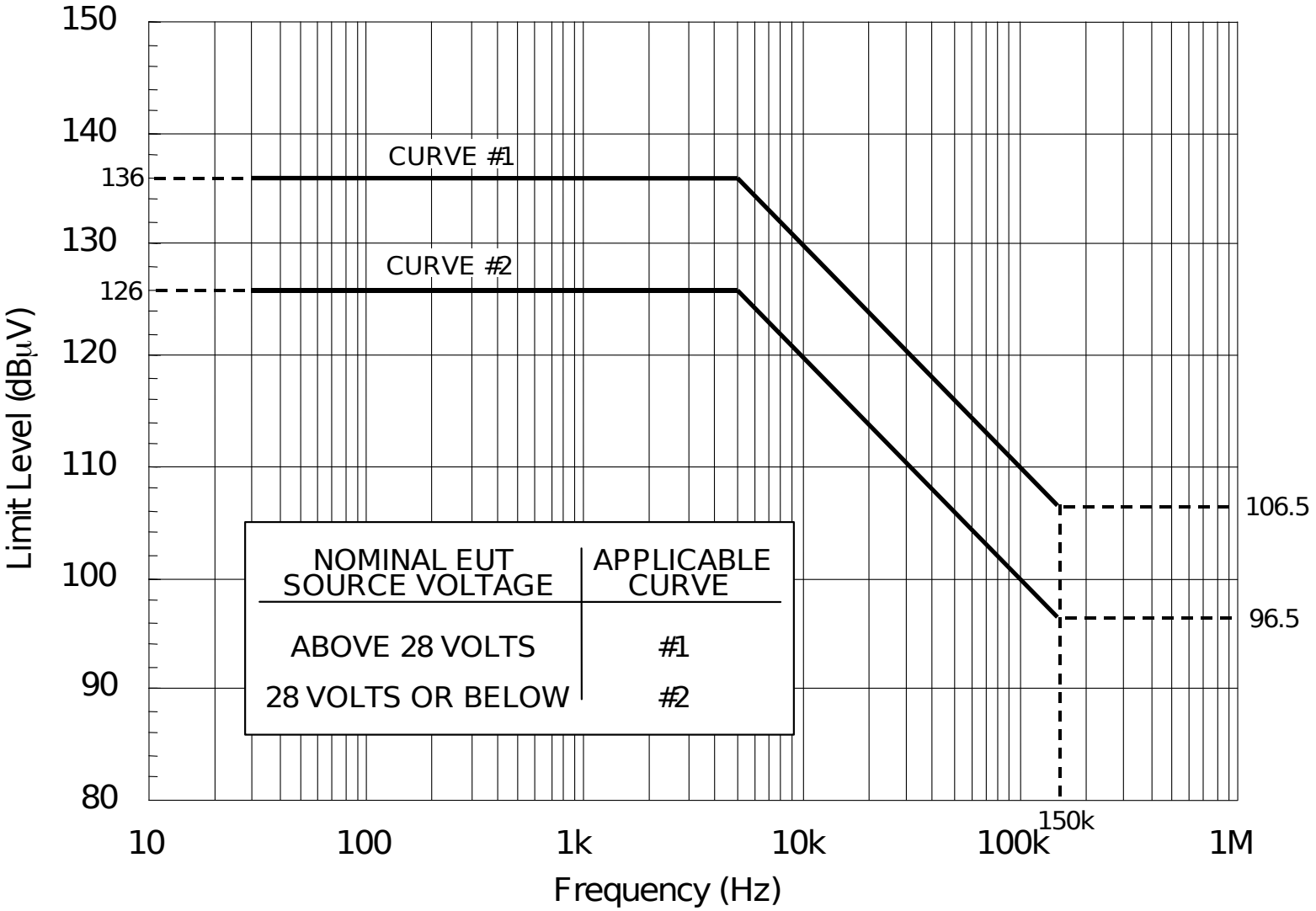
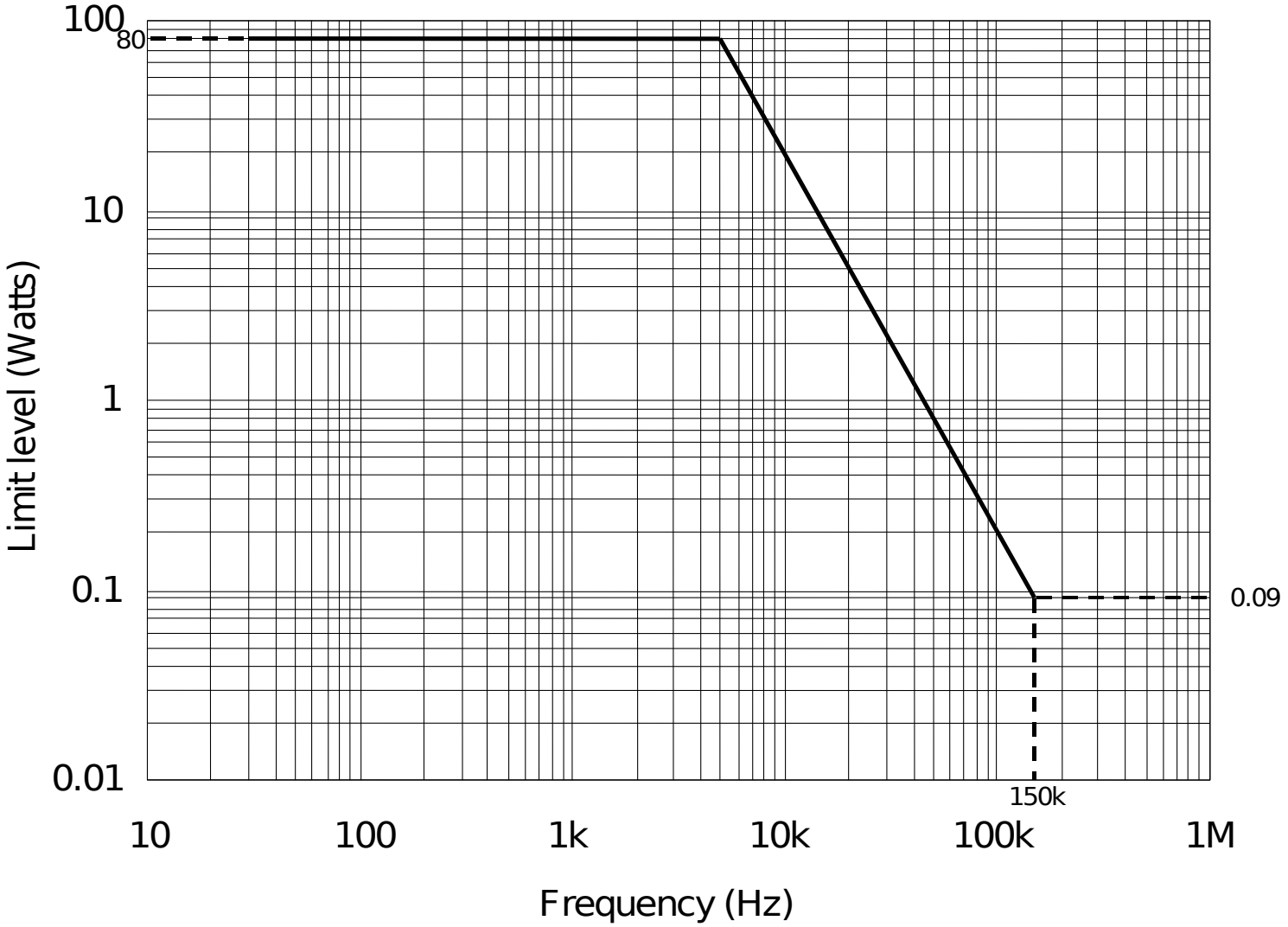


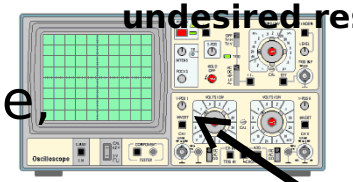
Figure CS101-2. CS101 Power Limit For All Applications

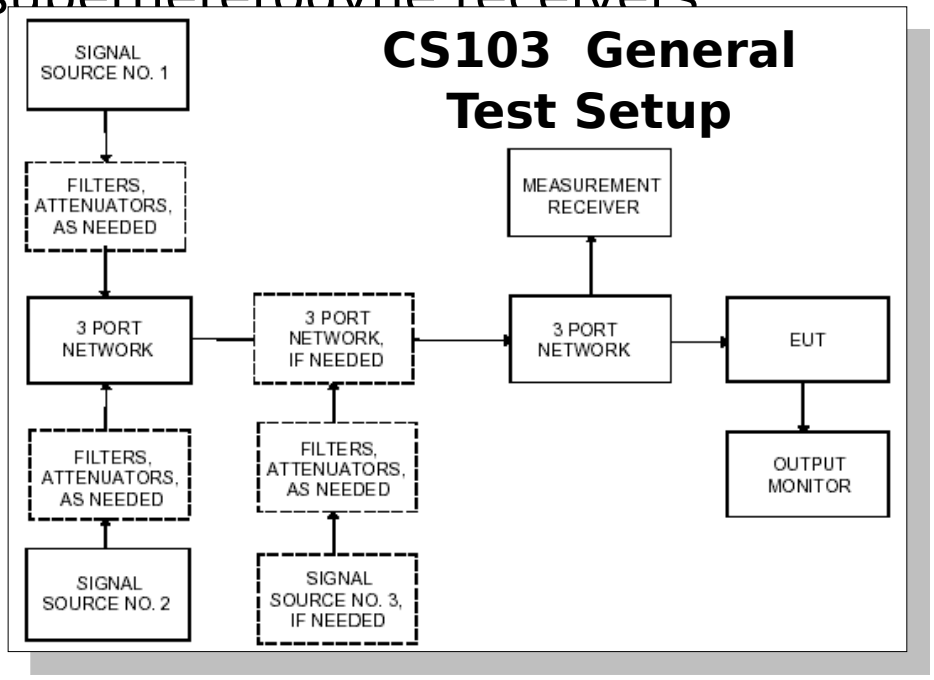


5.8. CS103, Conducted Susceptibility, Antenna Port, 15 kHz to 10 GHz

- Intent is to control the response of antenna connected receiving subsystems to in-band signals resulting from potential intermodulation products of two signals outside of the intentional passband of the subsystem
- Most applicable to fixed frequency, tunable, superheterodyne receivers

The basic concept is to combine two out-of-band signals (one modulated and one CW) and apply to the antenna port of receiver while monitoring it for an undesired response

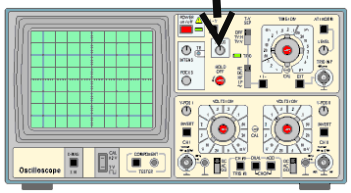




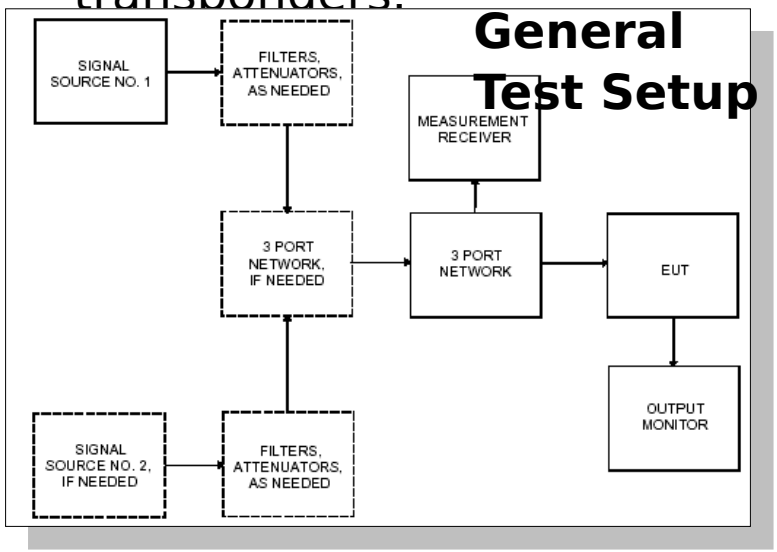
5.9. CS104, Conducted Susceptibility, Antenna Port, 30 Hz to 20 GHz

- Intent of CS104 is to control response of antenna connected receiving subsystems to signals outside intentional passband of the subsystem.
  - Most applicable to fixed frequency, tunable, superheterodyne receivers.
  - Front-end rejection testing can be applied to a variety of receiving subsystems such as receivers, RF amplifiers, transceivers, and transponders.

No test procedures are provided - The basic concept with this test procedure is to apply out-of-band signals to the antenna port of the receiver while monitoring the receiver

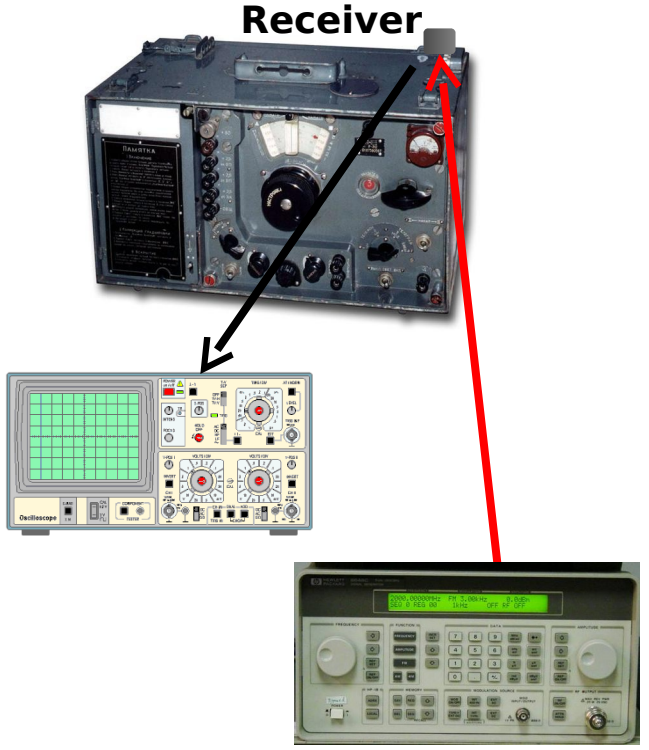


CS104 General Test Setup

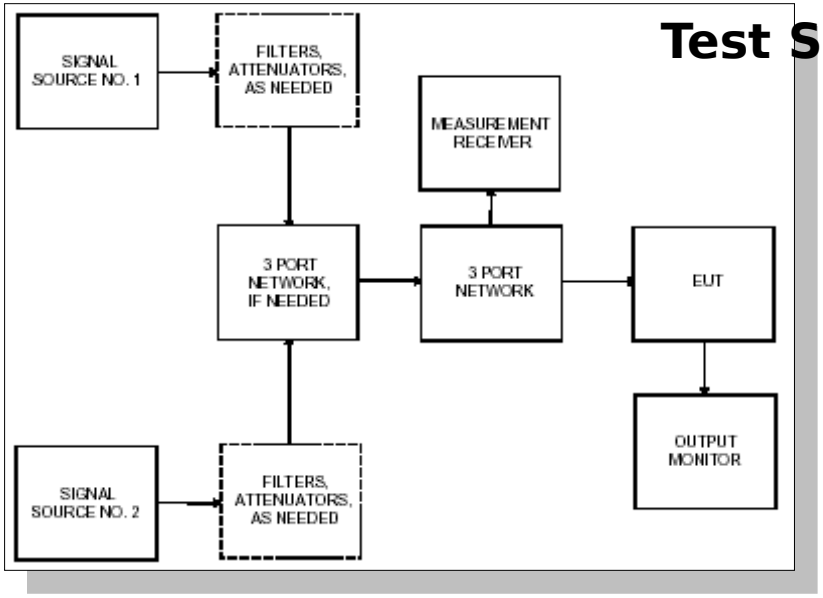


5.10. CS105, Conducted Susceptibility, Antenna Port, 30 Hz to 20 GHz

- Intent is to control the response of antenna connected receiving subsystems to modulation being transferred from an out-of-band signal to an in-band signal.
- Results from a strong, out-of-band signal near the operating frequency of the receiver
- Should be considered only for receivers, transceivers, amplifiers, and the like, which extract information from the amplitude modulation of a carrier.
- Cross modulation testing should be applied only to receiving subsystems such as receivers, RF amplifiers, transceivers and transponders which extract information from the amplitude modulation of a carrier.



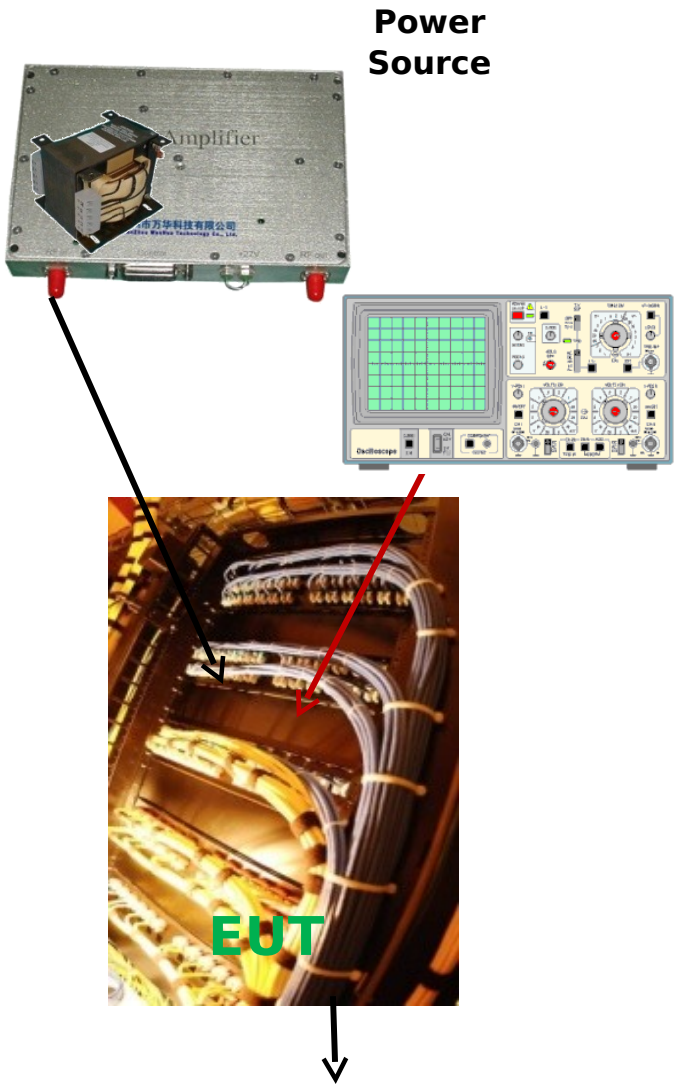
CS105 General Test Setup



The basic concept of this test is to apply a modulated signal out-of-band to the receiver and to determine whether the modulation is transferred to an unmodulated signal at the receiver's tuned frequency resulting in an undesired response.

5.11. CS106, Conducted Susceptibility, Transients, Power Leads

- Applicable to power input leads on surface ships and submarines that obtain power from the platform's primary power source that are not part of the EUT.
- Primary concern is to ensure that performance is not degraded from voltage transients from shipboard power systems



5.11. CS109, Conducted Susceptibility, Structure Current, 60 Hz to 100 GHz

- Specialized test intended for very sensitive equipment (1 uV or better) such as tuned receivers operating over the frequency range of the test.
- Intent is to ensure that equipment does not respond to magnetic fields caused by currents flowing in platform structure

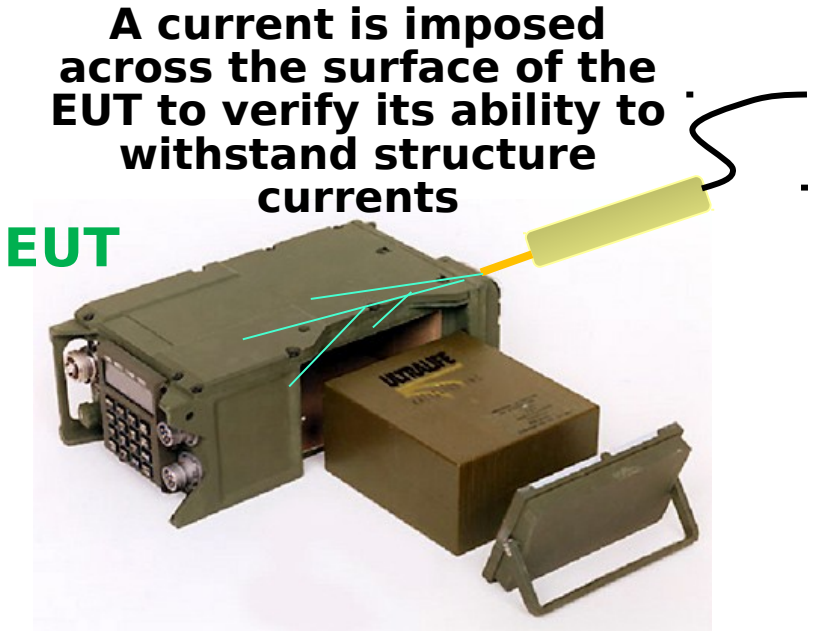
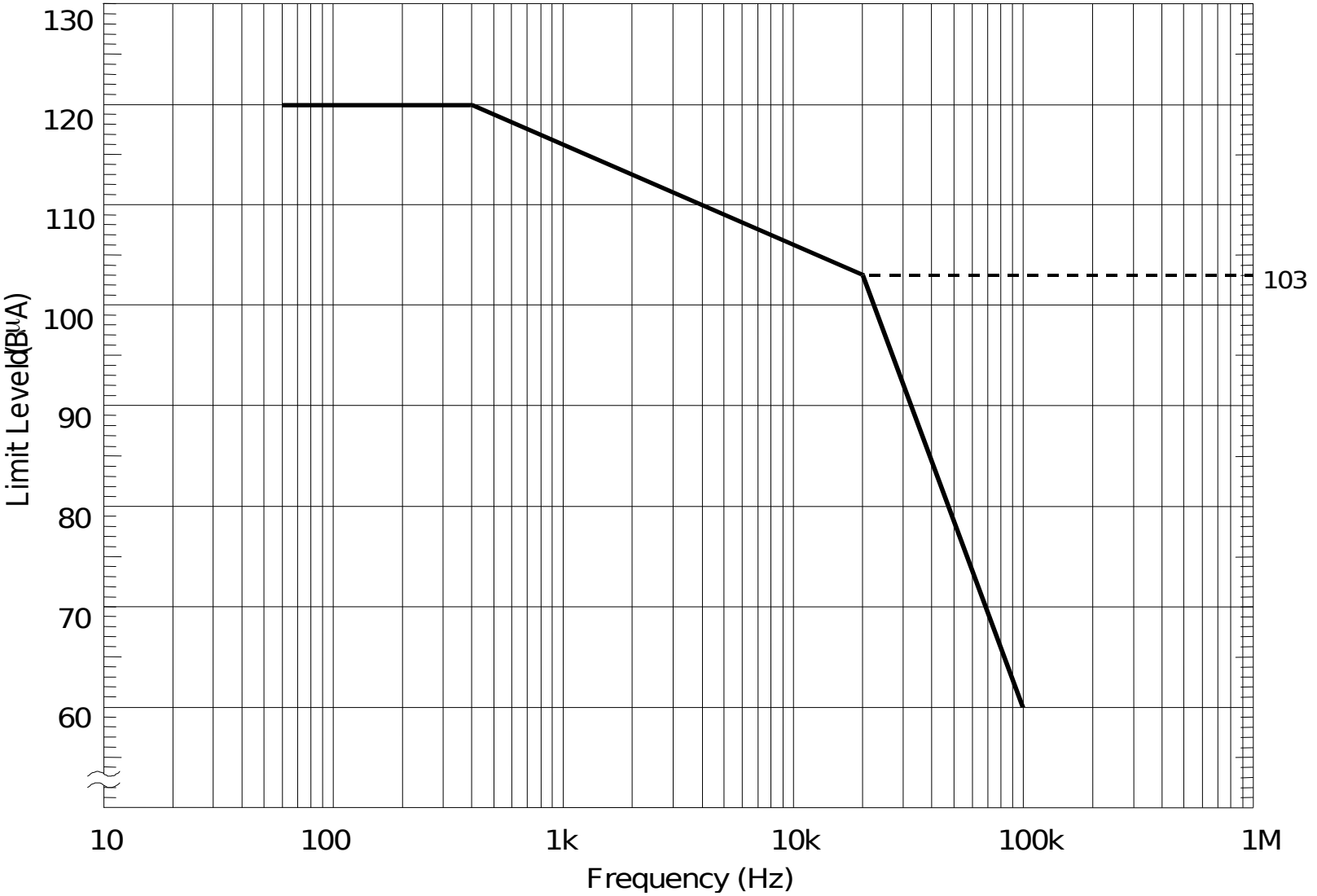
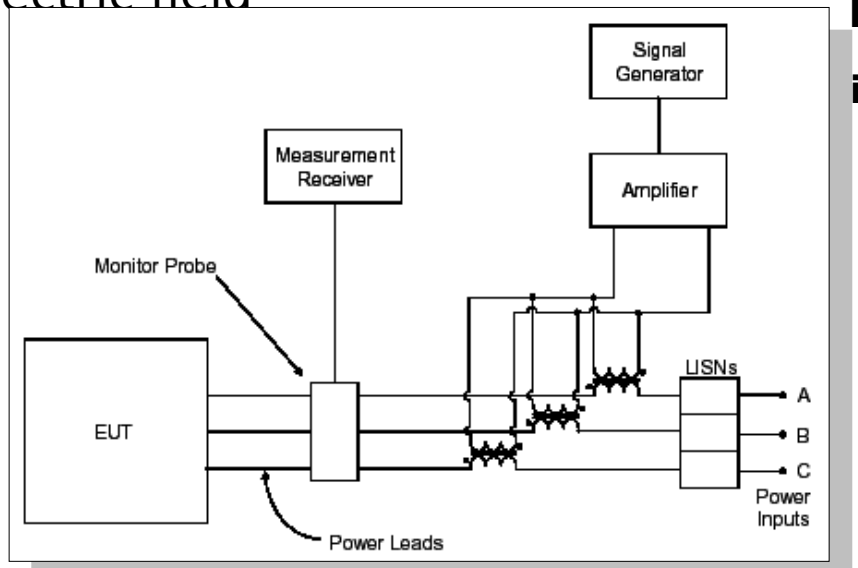


Figure CS109-1. CS109 Limit For All Applications



5.12. CS114, Conducted Susceptibility, Bulk Cable Injection, 10 kHz to 200 MHz

- Applicable to all electrical cables interfacing with the EUT enclosures.
- Concept is to simulate currents developed on platform cabling from electromagnetic fields generated by antenna transmissions both on and off the platform.
- Aircraft carrier hangar deck EME test data from 9 aircraft carriers showed significant HF electric field



CS114 alternate test setup, three phase ungrounded power system.

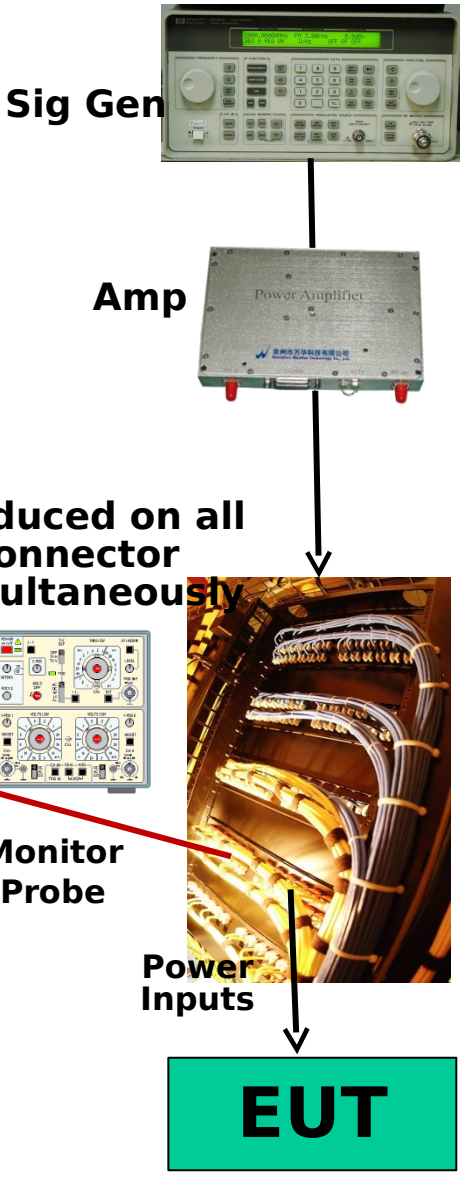


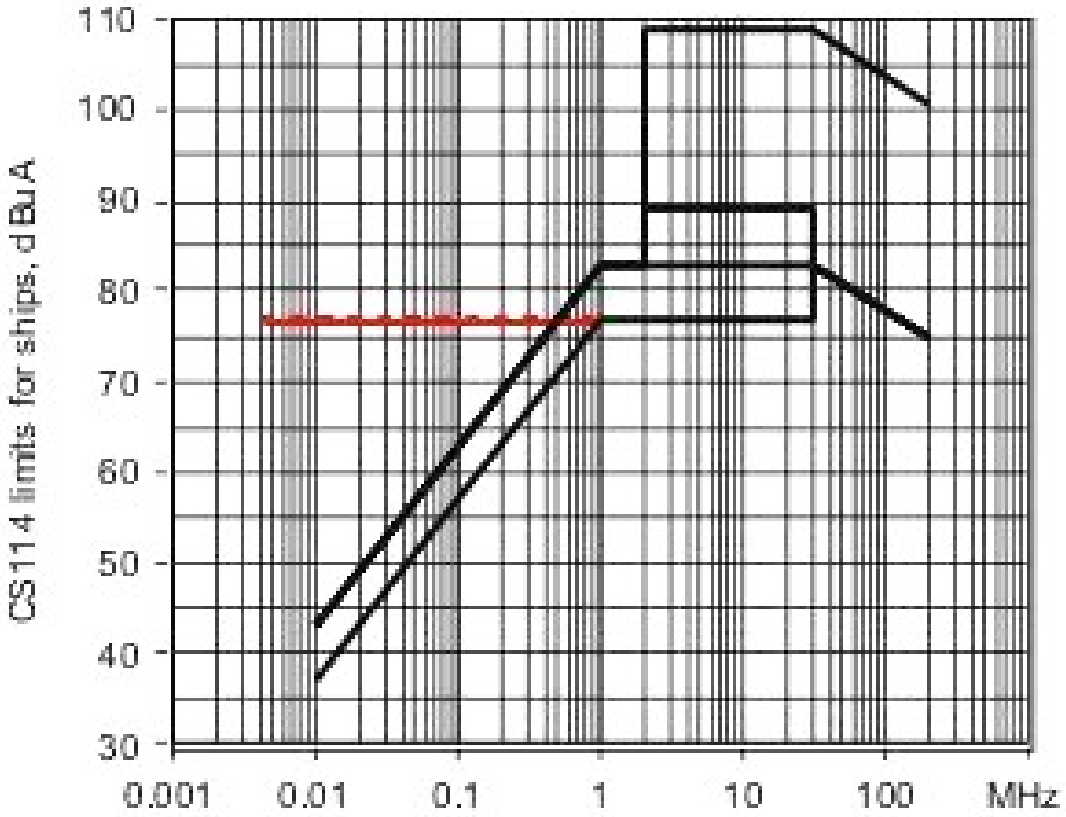
Table VI. CS114 Limit Curves

Frequency Range / Platform		Limit Curve Numbers Shown in Figure CS-114-1 And Limits							
		Aircraft (External or Safety Critical)	Aircraft (Internal)	All Ships (Above Decks) and Submarines (External)*	Ships (Metallic) (Below Decks)	Ships (Non-Metallic) (Below Decks) **	Submarine (Internal)	Ground	Space
4 kHz – 1 MHz	Navy	-	-	**77 dBuA**	**77 dBuA**	**77 dBuA**	**77 dBuA**	-	-
10 kHz – 2 MHz	Army	5	3	2	2	2	1	3	3
	Navy	5	3	2	2	2	1	2	3
	Air Force	5	3	-	-	-	-	2	3
2 MHz – 30 MHz	Army	5	5	5	2	4	1	4	3
	Navy	5	5	5	2	4	1	2	3
	Air Force	5	3	-	-	-	-	2	3
30 MHz – 200 MHz	Army	5	5	5	2	2	2	4	3
	Navy	5	5	5	2	2	2	2	3
	Air Force	5	3	-	-	-	-	2	3

*** For equipment located external to the pressure hull of a submarine but within the superstructure, use SHIPS (METALLIC) (BELOW DECKS)**

**** For equipment located in the hanger deck of Aircraft Carriers.**

Table VI. CS114 Limit Curves

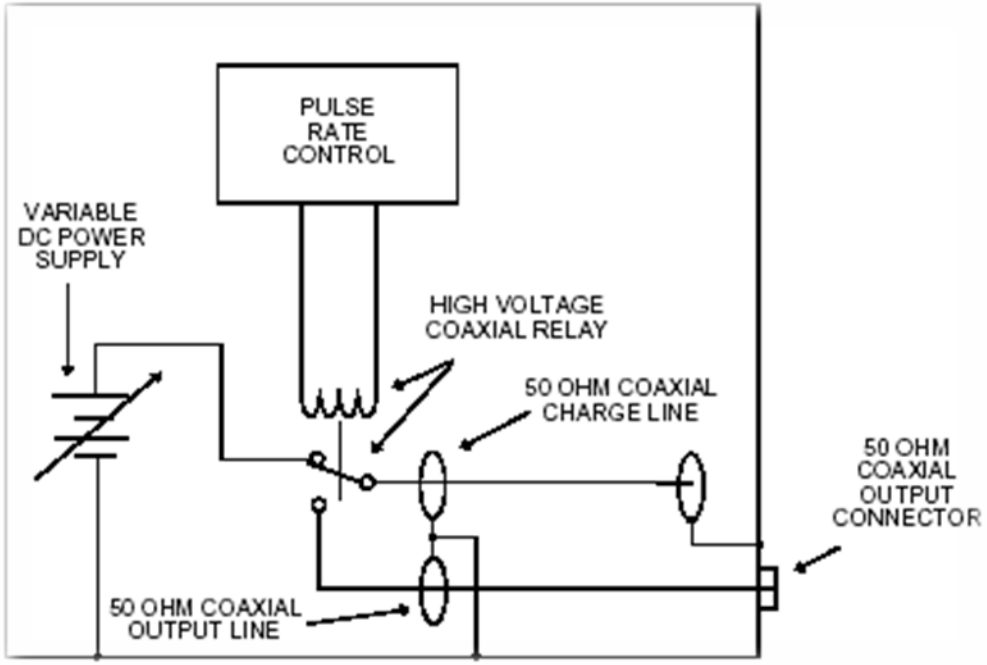


CS114 limits for Navy ships of all kinds (black) and extension of limit for power inputs (red dashed)

Figure CS114-1. CS114 Calibration Limit For All Applications

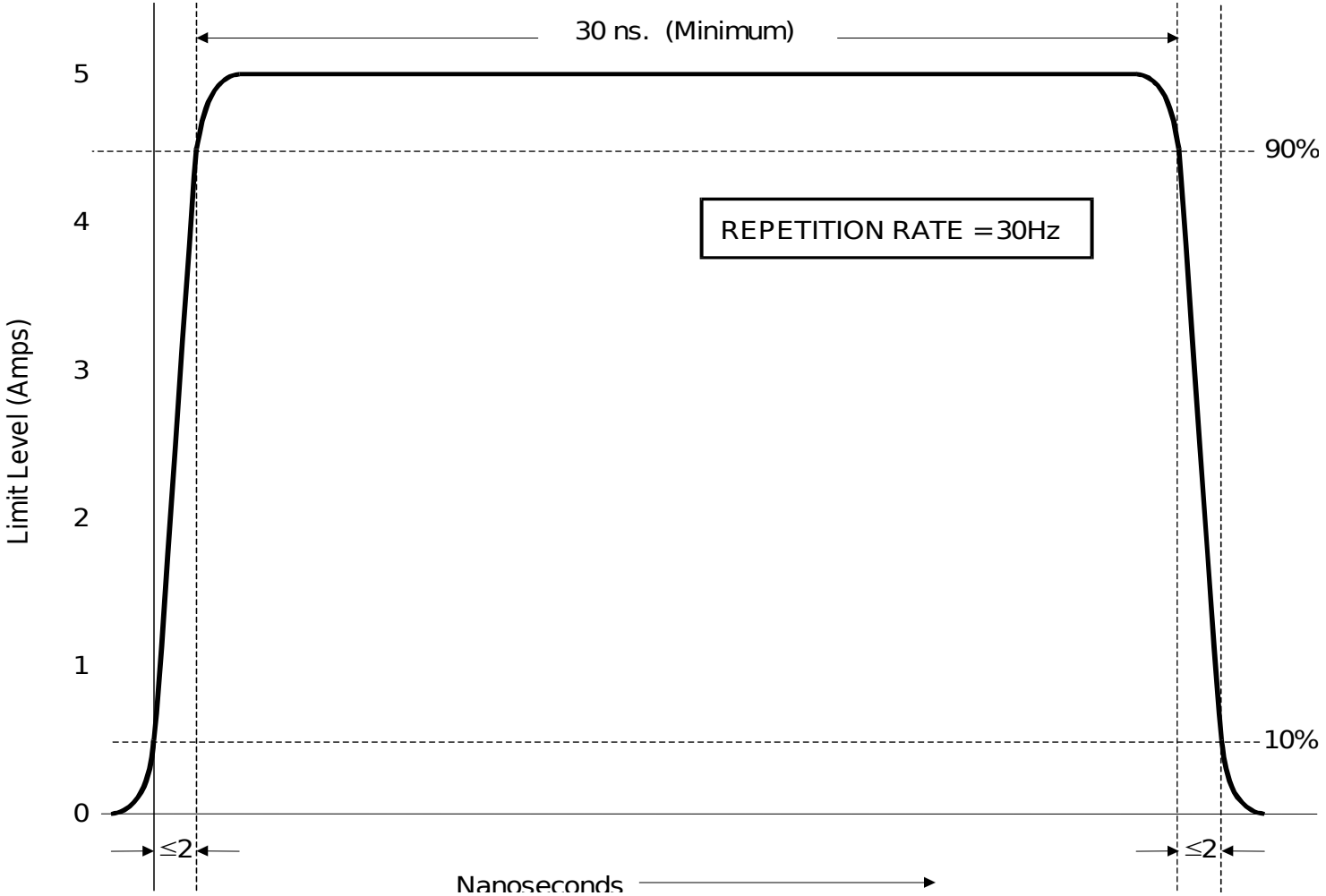
5.13. CS115, Conducted Susceptibility, Bulk Cable Injection, Impulse Excitation

- Applicable to all electrical cables interfacing with EUT enclosures.
- Concern is to protect equipment from fast rise and fall time transients that may be present due to platform switching operations and external transient environments such as lightning and electromagnetic pulse.
- Replaces "chattering relay" type requirements (RS06 in MIL-STD-461C)
- The excitation waveform from the generator is a trapezoidal pulse.


PULSE RATE CONTROL
VARIABLE DC POWER SUPPLY
HIGH VOLTAGE COAXIAL RELAY
50 OHM COAXIAL CHARGE LINE
50 OHM COAXIAL OUTPUT CONNECTOR
50 OHM COAXIAL OUTPUT LINE

A pulse generator required by CS115 is essentially the same as impulse generators used to calibrate measurement receivers except that the pulse width is much longer. A direct current power supply is used to charge the capacitance of an open-circuited 50 ohm coaxial line. The high voltage relay is then switched to the output coaxial line to produce the pulse. The pulse width is dependent upon the length of the charge line. The relay needs to have bounce-free contact operation.

Figure CS115-1. CS115 Signal Characteristics For All Applications



5.14. CS116, Conducted Susceptibility, Damped Sinusoidal Transients, Cables and Power Leads, 10 kHz to 100 MHz

- Applicable to electrical cables interfacing with each EUT enclosure and also on each power lead.
- Concept is to simulate electrical current and voltage waveforms occurring in platforms from excitation of natural resonances.
- Intent is to control waveform as a damped sine.
- Wide frequency coverage accounts for a wide range of conditions.
- Switching Transients within the platform can also result in similar waveforms.
- Test Procedure
  - Common mode test on the cable bundle simulates the EM field coupling mechanisms
  - Power lead test addresses differential type signals present from switching in the power system
  - The signal can be applied to wires on individual connector pins or to

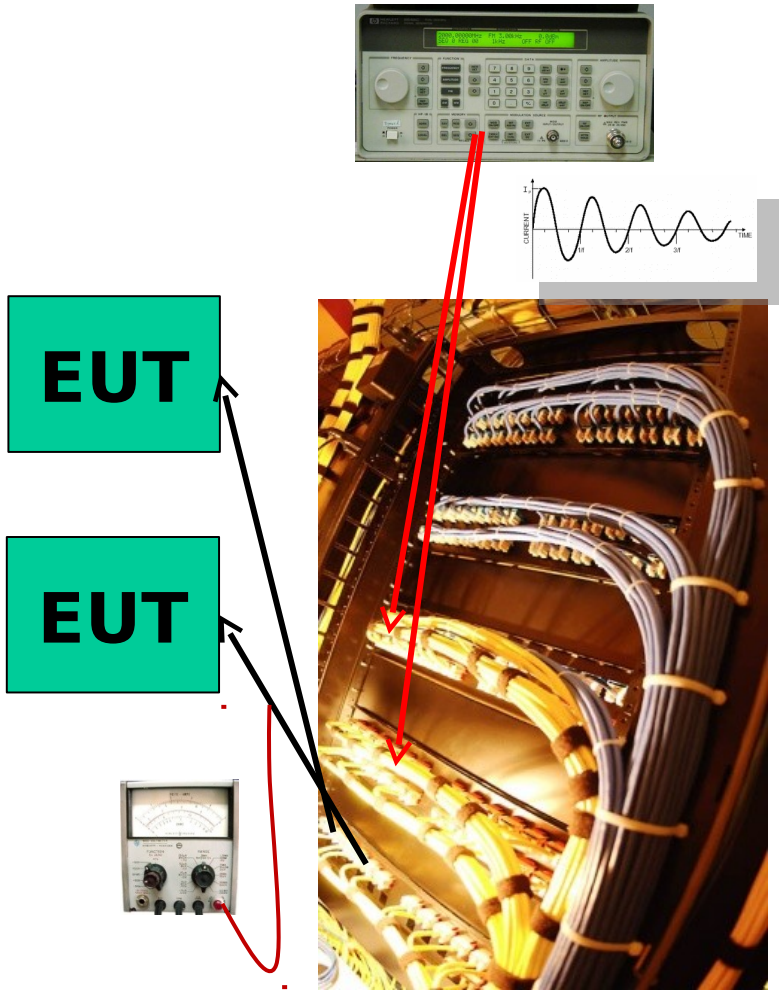
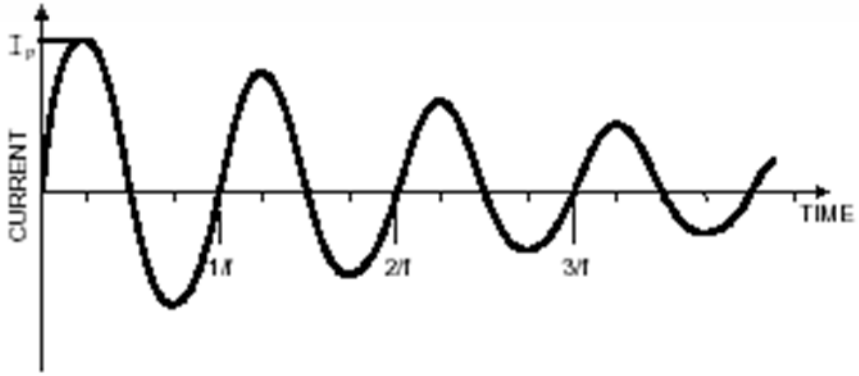


Figure CS116-1. Typical CS116 Damped Sinusoidal Waveform



NOTES: 1. Normalized waveform: $e^{-(\pi f t/Q)}\sin(2\pi ft)$

Where:
f = Frequency (Hz)
t = Time (sec)
Q = Damping factor, 15±5

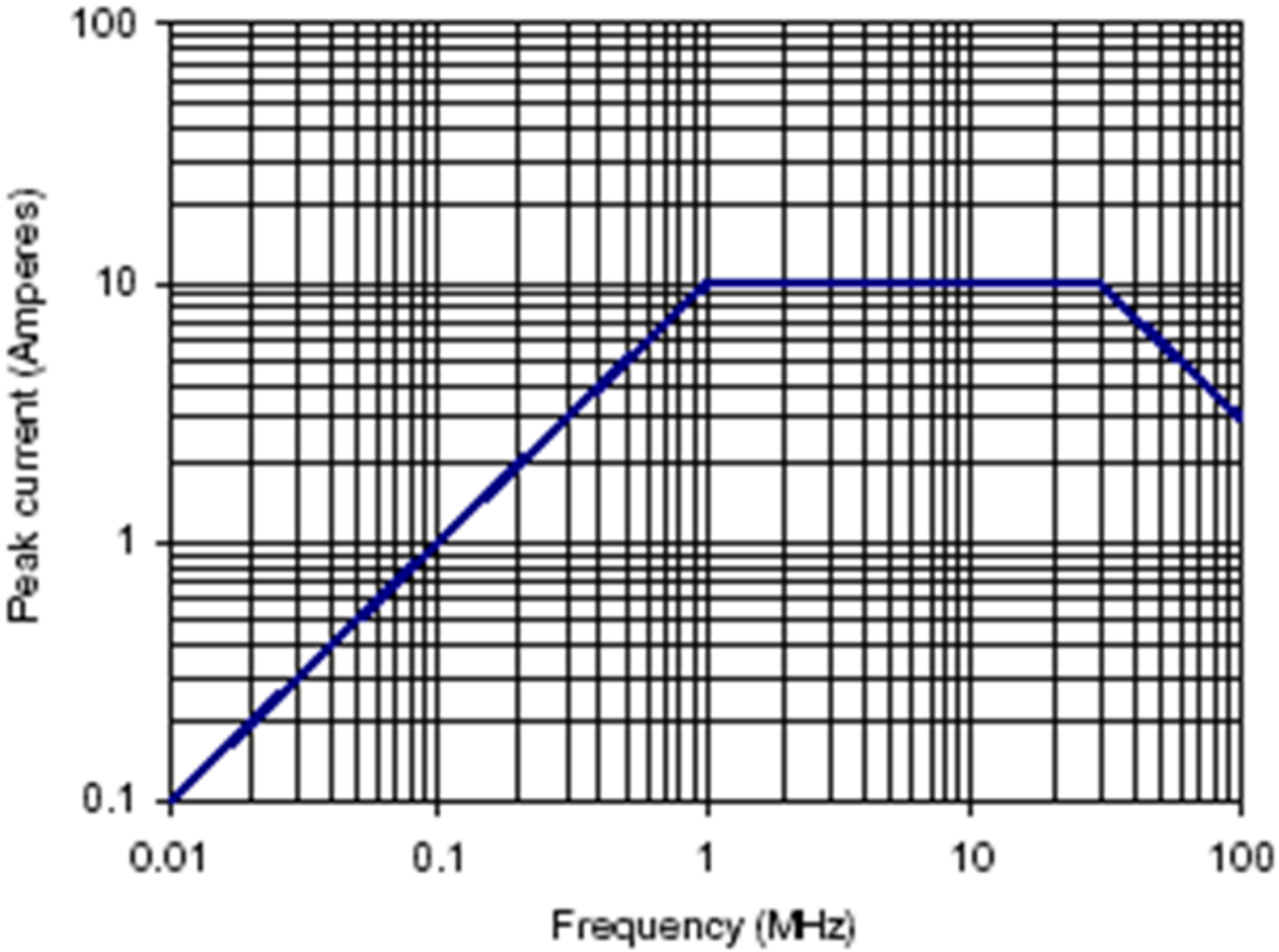
2. Damping factor (Q) shall be determined as follows:

$$Q = \frac{\pi(N - 1)}{\ln(I_P/I_N)}$$

Where:
Q = Damping factor
N = Cycle number (i.e. N = 2, 3, 4, 5,...)
I_p = Peak current at 1st cycle
I_N = Peak current at cycle closest to 50% decay
ln = Natural log

3. I_P as specified in Figure CS116-2

Figure CS116-2. CS116 Limit For All Applications



5.15. RE101, Radiated Emissions, Magnetic Field, 30 Hz to 100 kHz

- Applicable for radiated emissions from equipment and subsystem enclosures, including electrical cable interfaces. For Navy aircraft, this requirement is applicable only for aircraft with an ASW capability.
- Specialized, intended to control magnetic fields for applications where equipment is present in the installation which is potentially sensitive to magnetic induction at lower frequencies.
- A 13.3 cm loop is specified for the test.
- This standard limits measurements to electrical interface connectors.

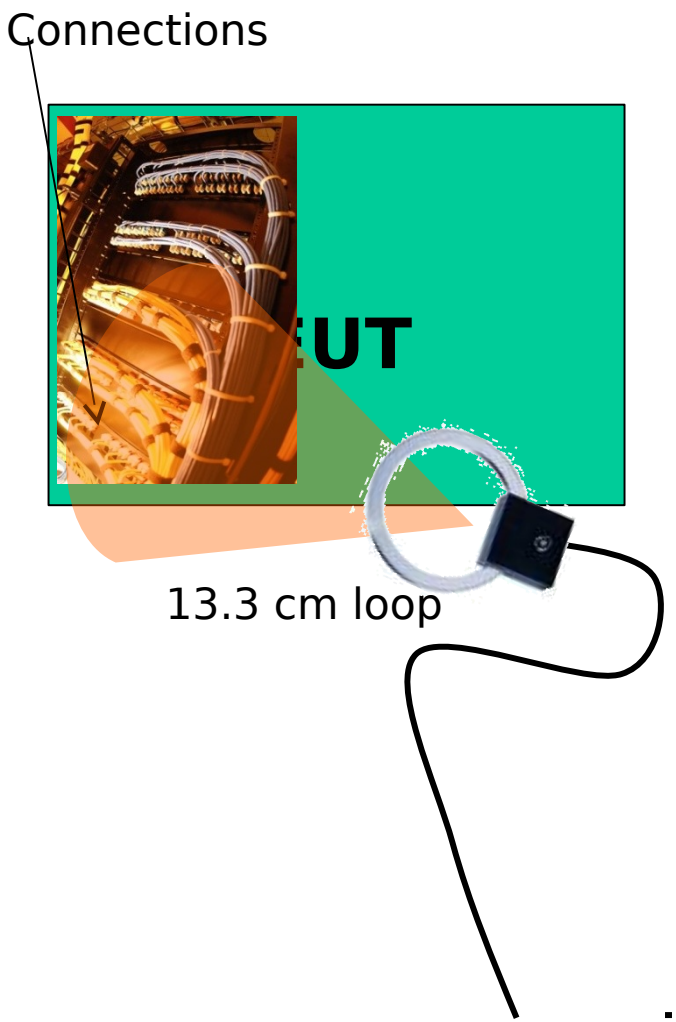


Figure RE101-1. RE101 Limit For All Army Applications

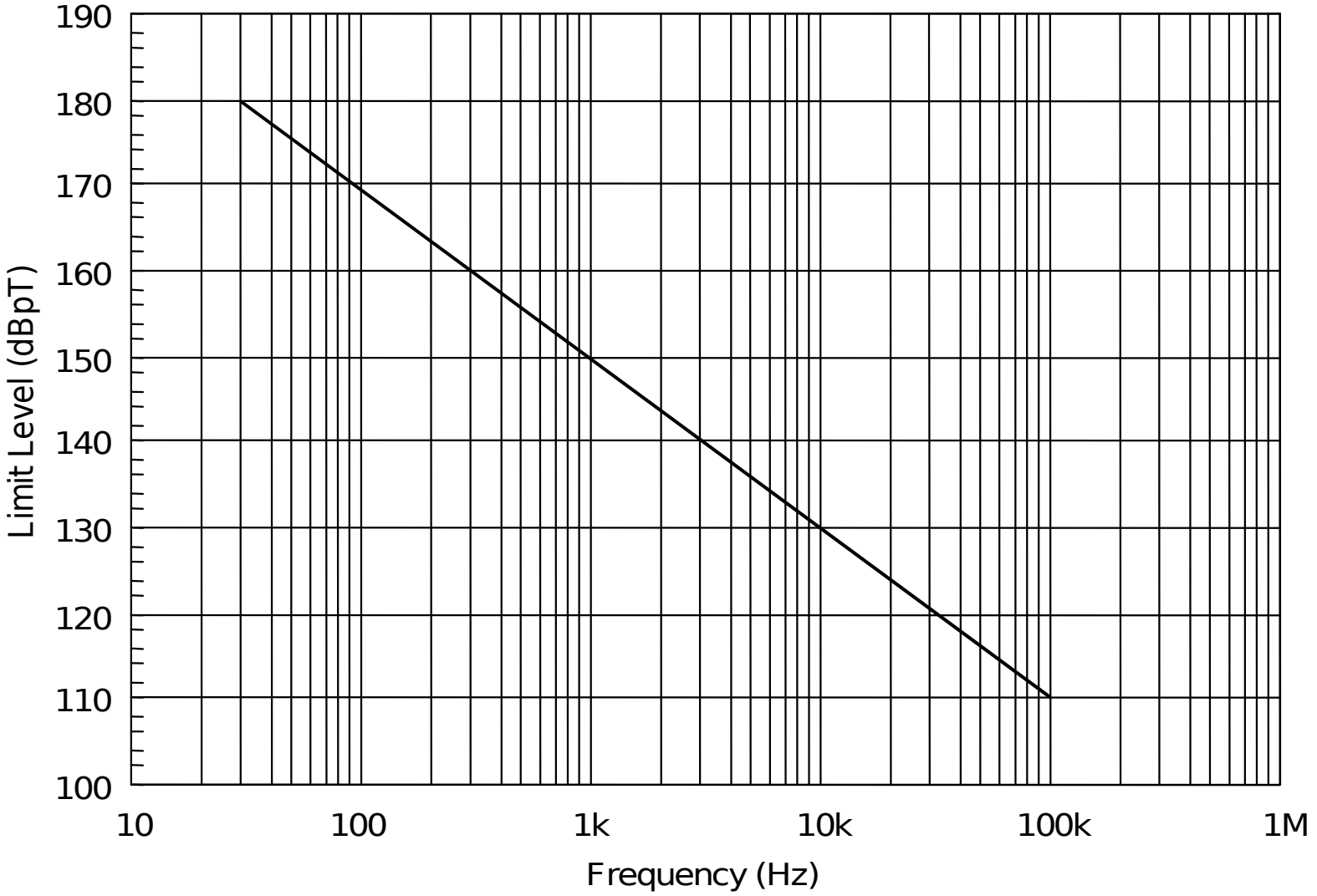
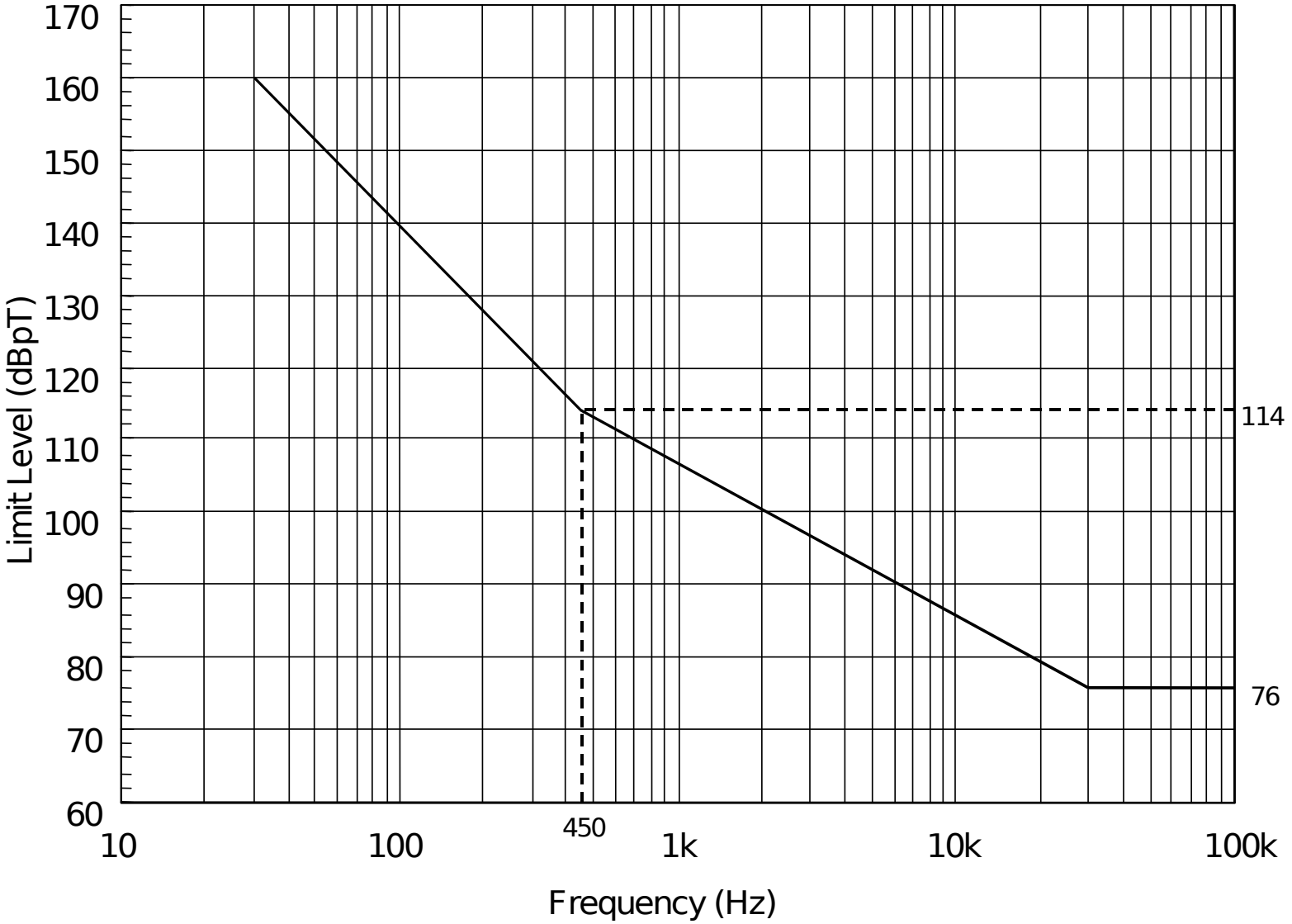
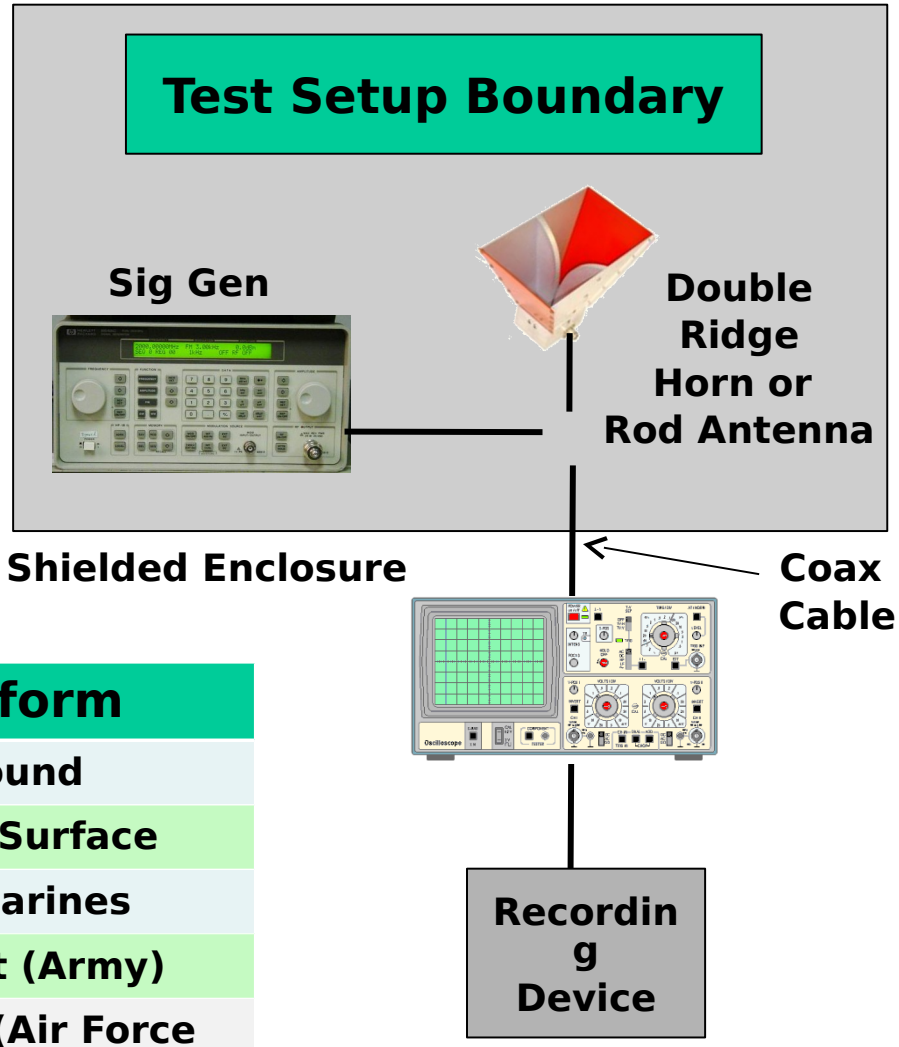


Figure RE101-2. RE101 Limit For All Navy Applications



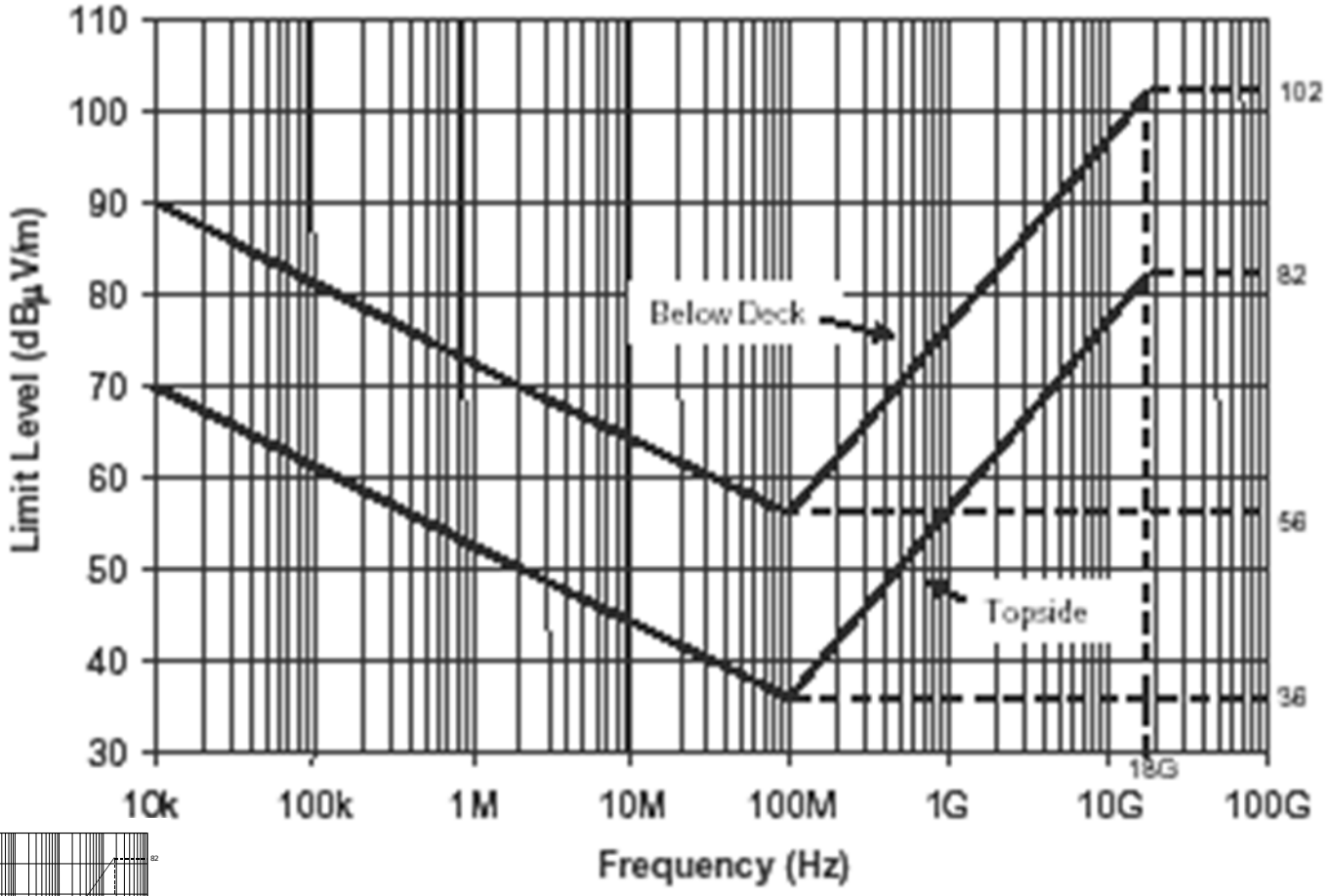
5.16. RE102, Radiated Emissions, Electric Field, 10 kHz to 18 GHz

- Applicable to electric field emissions from the EUT and associated cables.
- Intent is to protect sensitive receivers from interference coupled through the antennas associated with the receiver.
- Many tuned receivers have sensitivities on the order of 1 uV and are connected to intentional apertures (the antenna) that are constructed for efficient reception of energy in the operating range of the receiver.
- There is no implied relationship between this r[illegible] and RS103.



Frequency	Platform
12 MHz – 18 GHz *	Ground
10 kHz – 18 GHz *	Ships, Surface
10 kHz – 18 GHz *	Submarines
10 kHz – 18 GHz	Aircraft (Army)
2 MHz – 18 GHz *	Aircraft (Air Force Navy)
10 kHz – 18 GHz	Space

Figure RE102-1. RE102 Limit For Surface Ship Applications



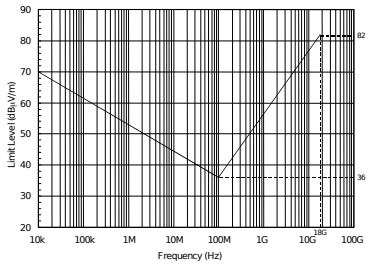


Figure RE102-2. RE102 Limit For Submarine Applications

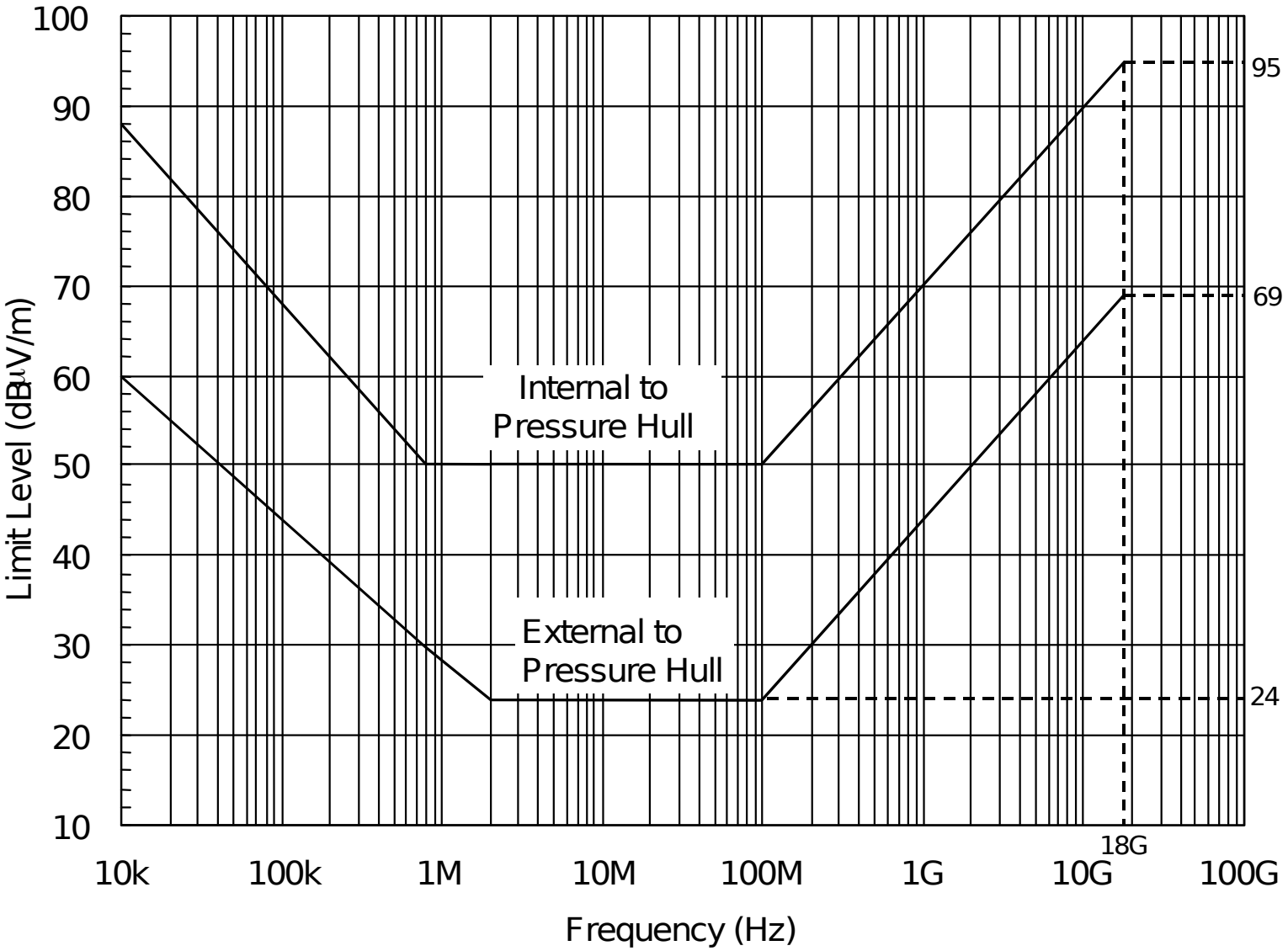


Figure RE102-3. RE102 Limit For Aircraft And Space System Applications

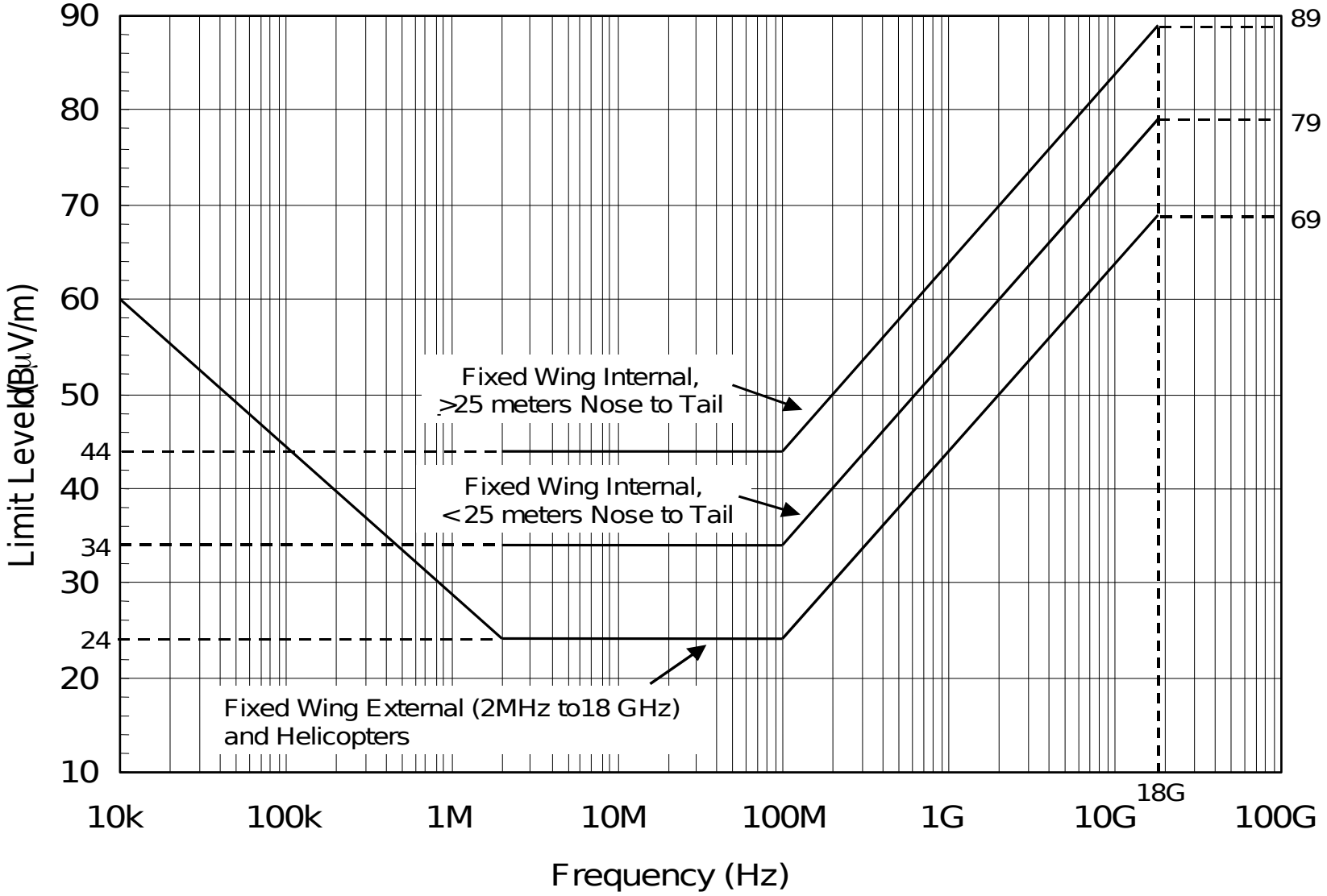
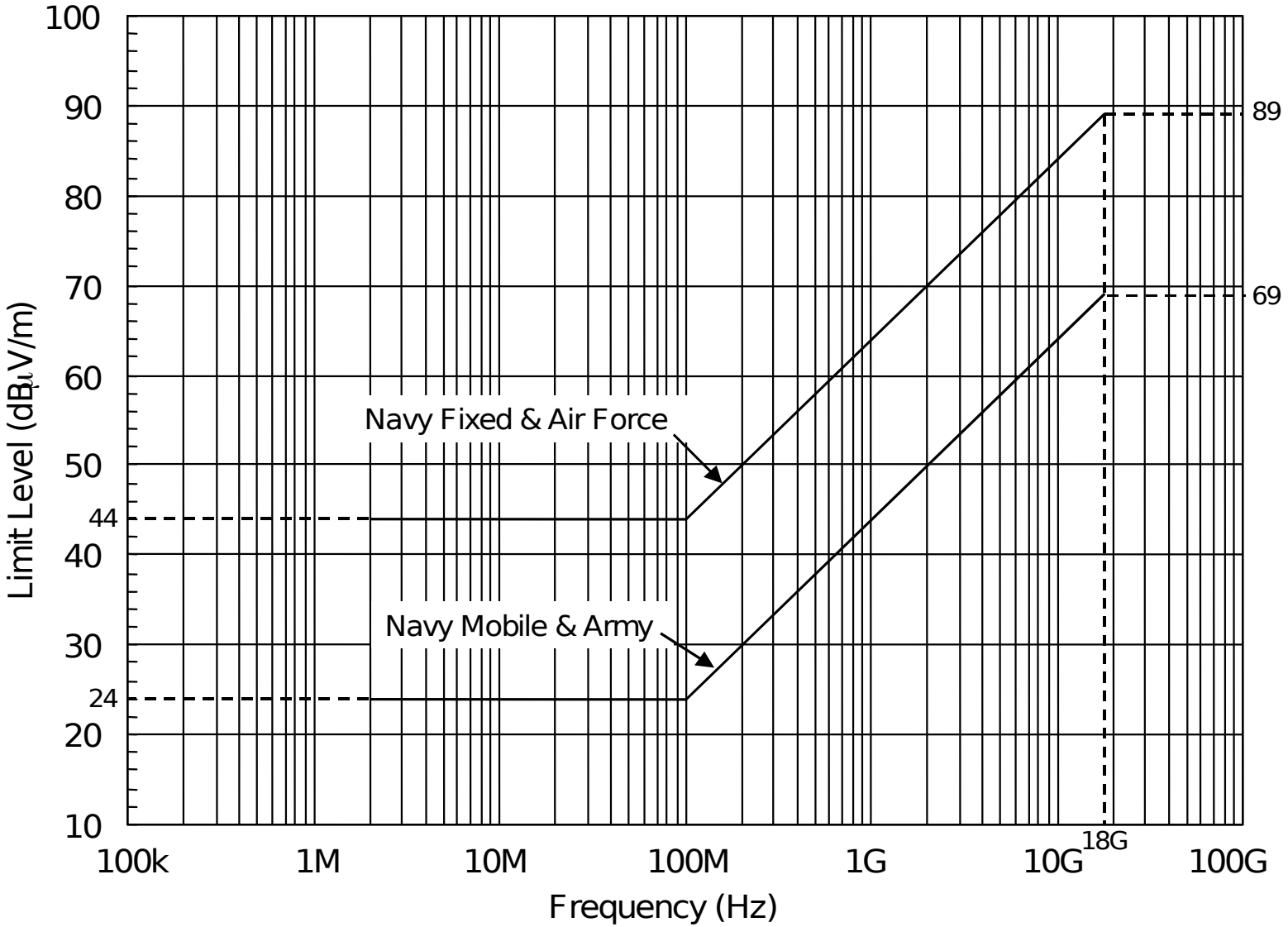
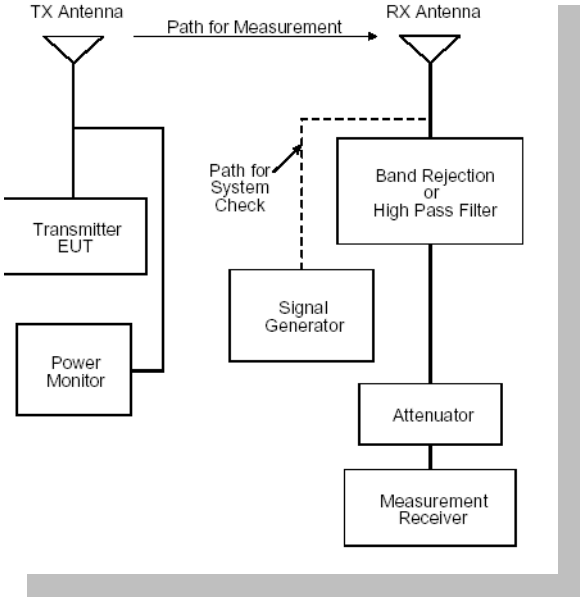


Figure RE102-4. RE102 Limit For Ground Applications

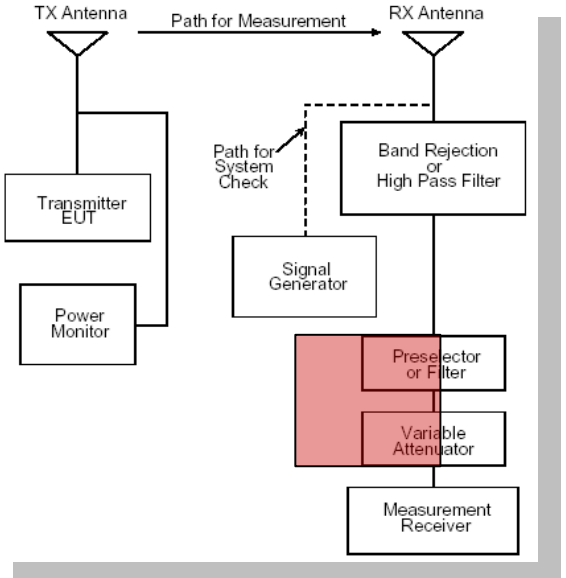


5.17. RE103, Radiated Emissions, Antenna Spurious and Harmonic Outputs, 10 kHz to 40 GHz

- Essentially identical with CE106 for transmitters in the transmit mode.
- No requirements for receivers or transmitters in the standby mode.
- The test procedure is laborious and will require a large open area to meet antenna separation distances.
- Minimum acceptable antenna separations are calculated based on antenna size and operating frequency of the EUT.
- Measurements in azimuth and elevation are required.
- Preamps may be required to enhance sensitivity.
- Coordinate with local frequency allocation authorities.
- RE103 Limits
  - Harmonics, except the second and third, and all other spurious emissions shall be at least 80 dB down from the level at the fundamental
  - The second and third harmonics shall be suppressed 50 + 10 log p (where p = peak power output in watts, at the fundamental) or 80 dB, whichever requires less suppression



Calibration and test setup for radiated harmonics and spurious emissions, 10 kHz to 1 GHz.



Calibration and test setup for radiated harmonics and spurious emissions, 1 GHz to 40 GHz.

5.18. RS101, Radiated Susceptibility, Magnetic Field, 30 Hz to 100 kHz

- Specialized test intended to ensure that performance of equipment susceptible to low frequency magnetic fields is not degraded.
- Due to its smaller size, the 4 cm loop sensor provides an accurate measure of the field near the axis of the radiating loop.
- Helmholtz coils generate a relatively uniform magnetic field that is more representative of the environment experienced on some platforms, particularly submarines. For this reason, the AC Helmholtz coil test option is preferred for submarine applications.
- Prior to initial use, the coils must be tested to ensure they are capable of generating the required magnetic flux densities from 30 Hz to 100 kHz.

4 cm loop or Helmholtz coil to Test each EUT connector

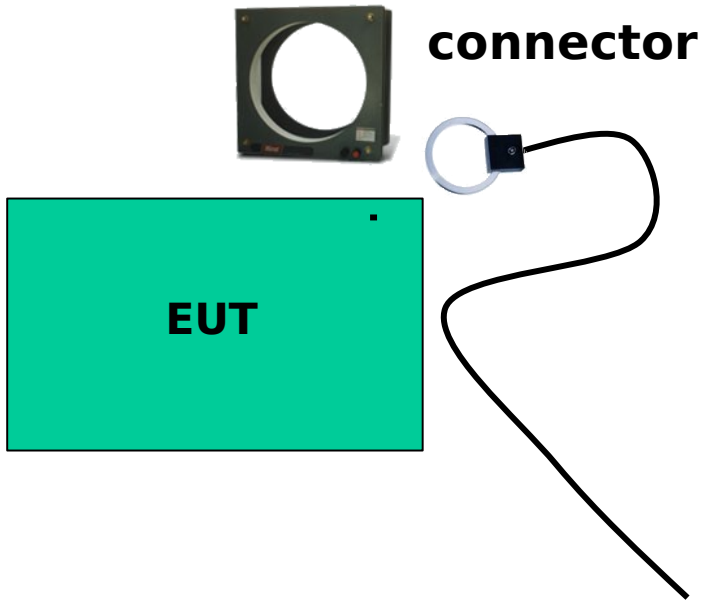


FIGURE RS101-1. RS101 Limit For All Navy Applications

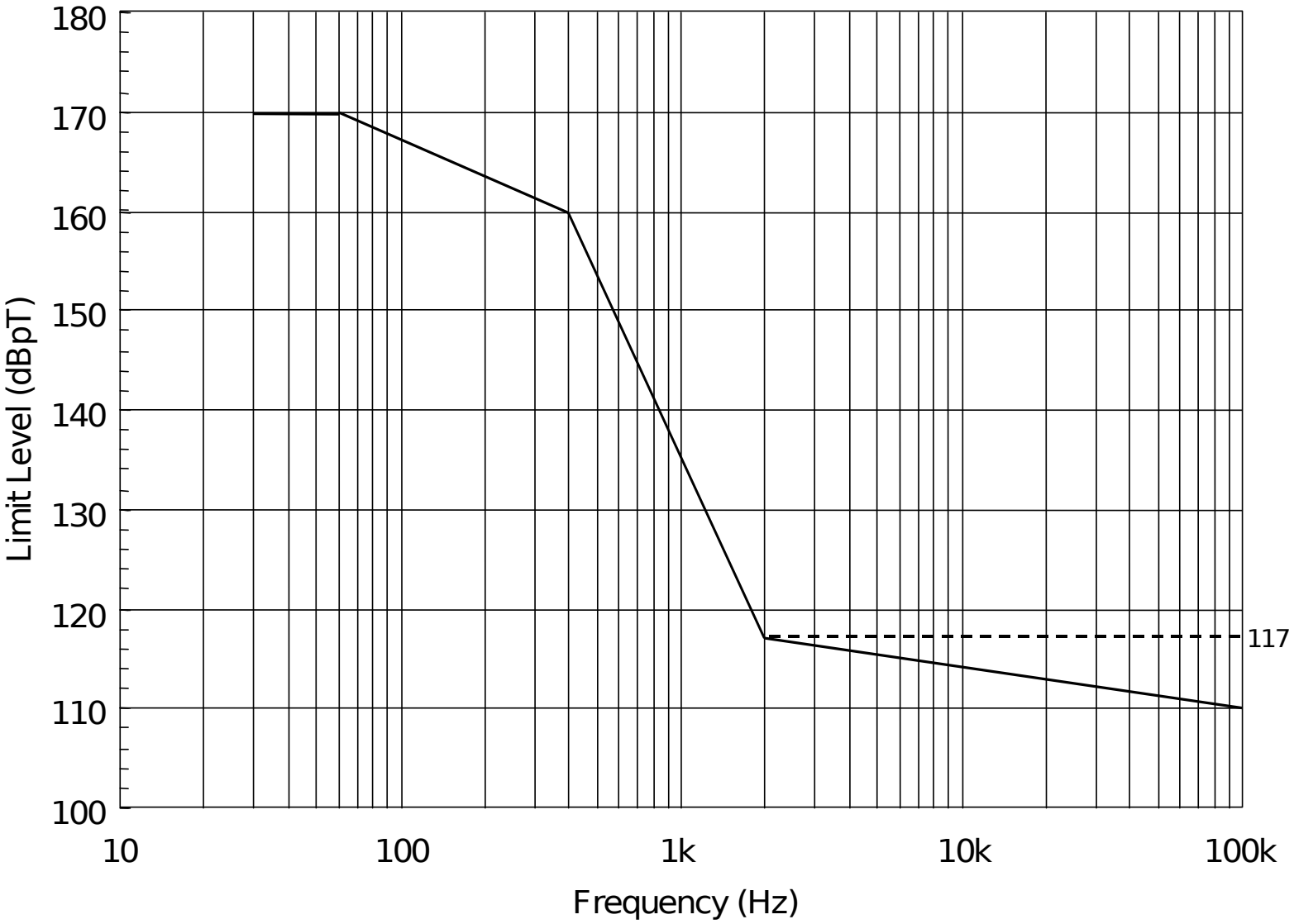
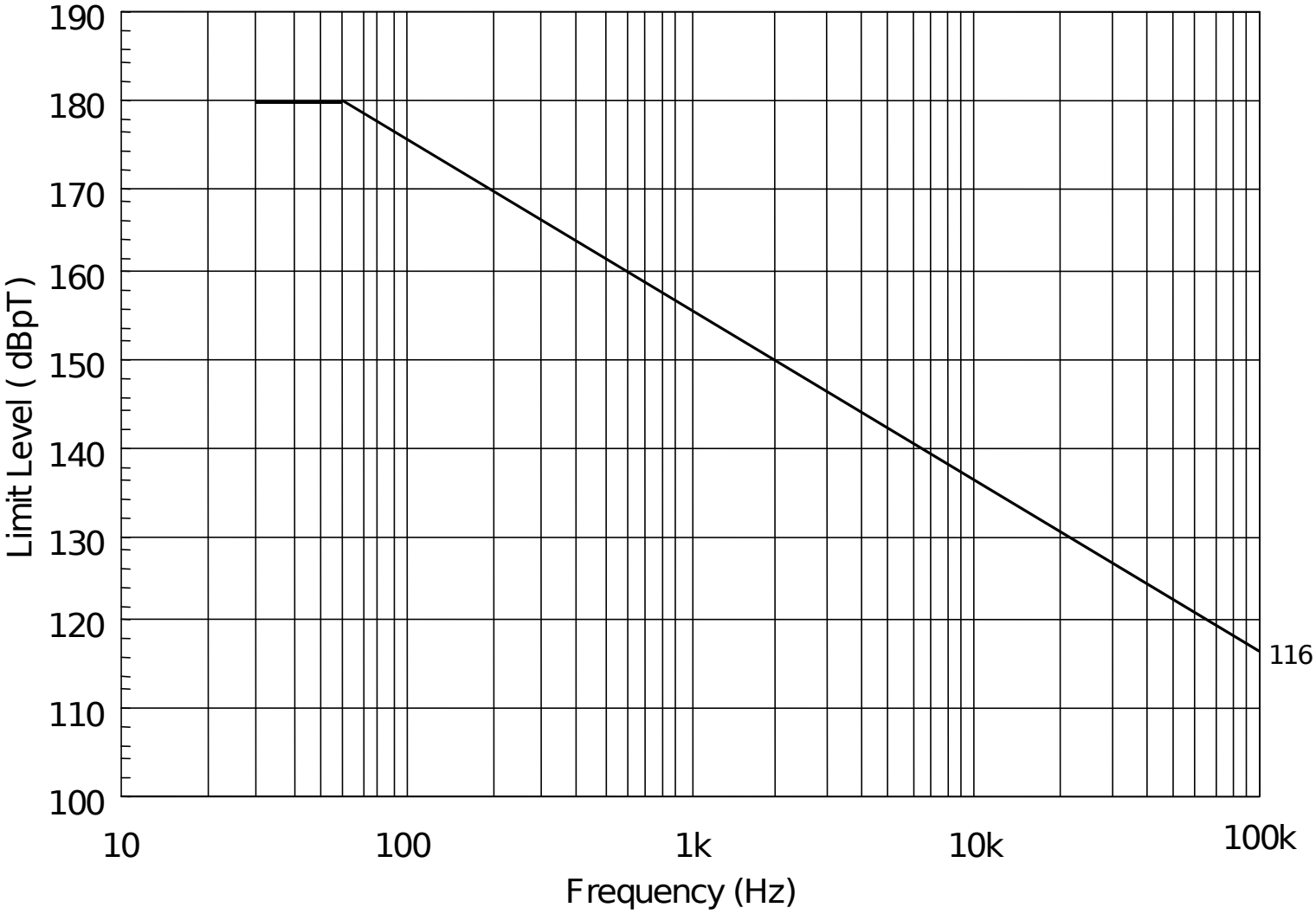


Figure RS101-2. RS101 Limit For All Army Applications



5.19. RS103, Radiated Susceptibility, Electric Field, 2 MHz to 40 GHz

- Applicable to both the EUT enclosures and EUT associated cabling
- Concern is to ensure that equipment will operate without degradation in the presence of electromagnetic fields generated by antenna transmissions both onboard and external to the platform.
- Limits for different platforms are based on levels expected to be encountered during the service life of the equipment
- Not necessarily worst-case environment to which the equipment may be exposed.
- For aircraft and ships, different limits are specified depending on whether the equipment receives

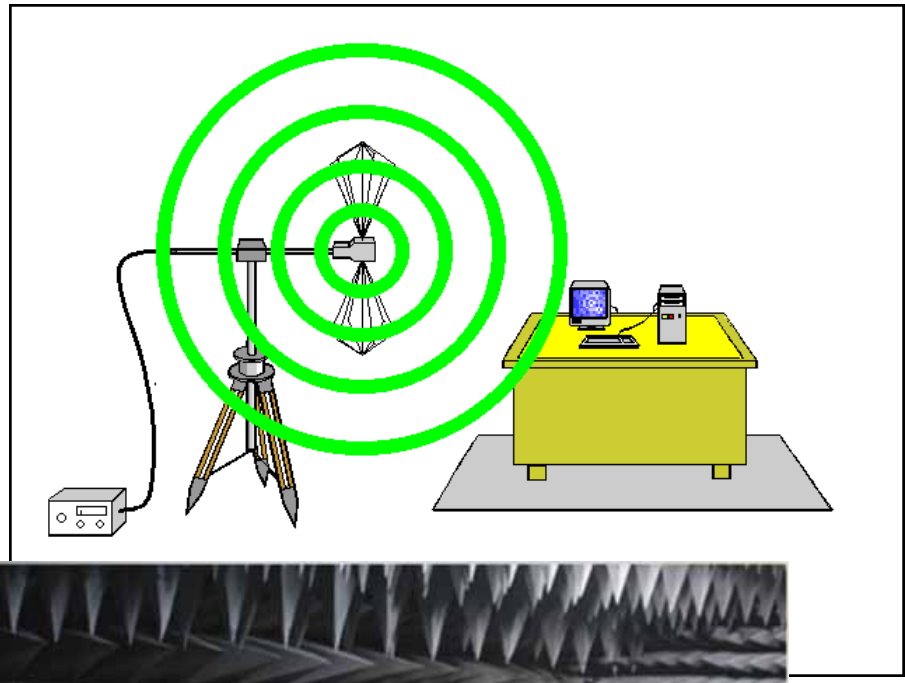


Table VII. RS103 Limits

Frequency Range	Platform	Limit Level (Volts/Meter) Aircraft (External or Safety Critical)	Aircraft (Internal)	All Ships (Above Decks) and Submarines (External)*	Ships (Metallic) (Below Decks)	Ships (Non-Metallic) (Below Decks) **	Submarine (Internal)	Ground	Space
2 MHz – 30 MHz	Army	200	200	**200**	**10**	**50**	**5**	50	20
	Navy	200	200	**200**	**10**	**50**	**5**	10	20
	Air Force	200	20	**-**	**-**	**-**	**-**	10	20
30 MHz – 1 GHz	Army	200	200	200	10	10	10	50	20
	Navy	200	200	200	10	10	10	10	20
	Air Force	200	20	-	-	-	-	10	20
1 GHz – 18 GHz	Army	200	200	200	10	10	10	50	20
	Navy	200	200	200	10	10	10	50	20
	Air Force	200	60	-	-	-	-	50	20
18 GHz – 40 GHz	Army	200	200	200	10	10	10	50	20
	Navy	200	60	200	10	10	10	50	20
	Air Force	200	60	-	-	-	-	50	20

*** For equipment located external to the pressure hull of a submarine but within the superstructure, use SHIPS (METALLIC) (BELOW DECKS)**

**** For equipment located in the hanger deck of Aircraft Carriers.**

5.20. RS105, Radiated Susceptibility, Transient Electromagnetic Field

- Intended for EUTs to withstand the fast rise time, free-field transient environment of EMP.
- Applies for equipment enclosures which are directly exposed to the incident field outside of the platform structure or for equipment inside poorly shielded or unshielded platforms.
- The electrical interface cabling should be protected in shielded conduit.
- The EMP field is simulated in the laboratory using bounded wave TEM radiators such as TEM cells and parallel plate transmission lines.
- Since the polarization of the incident EMP field in the installation is not known, the EUT must be

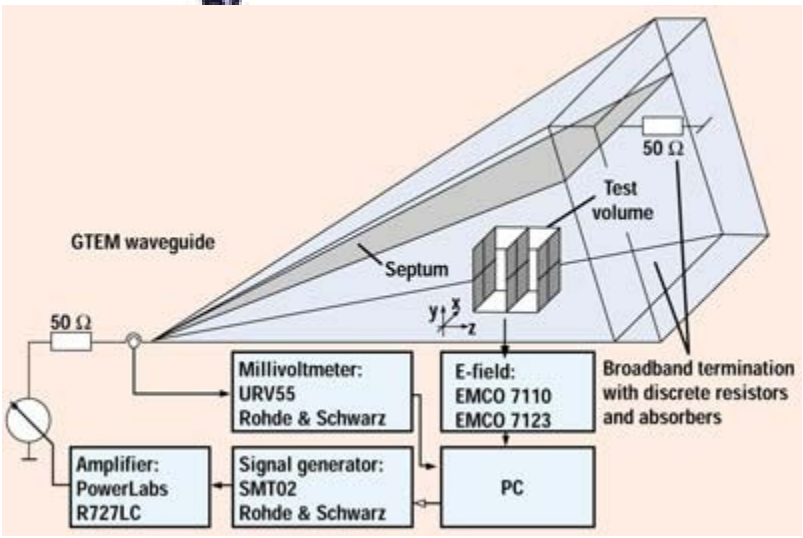
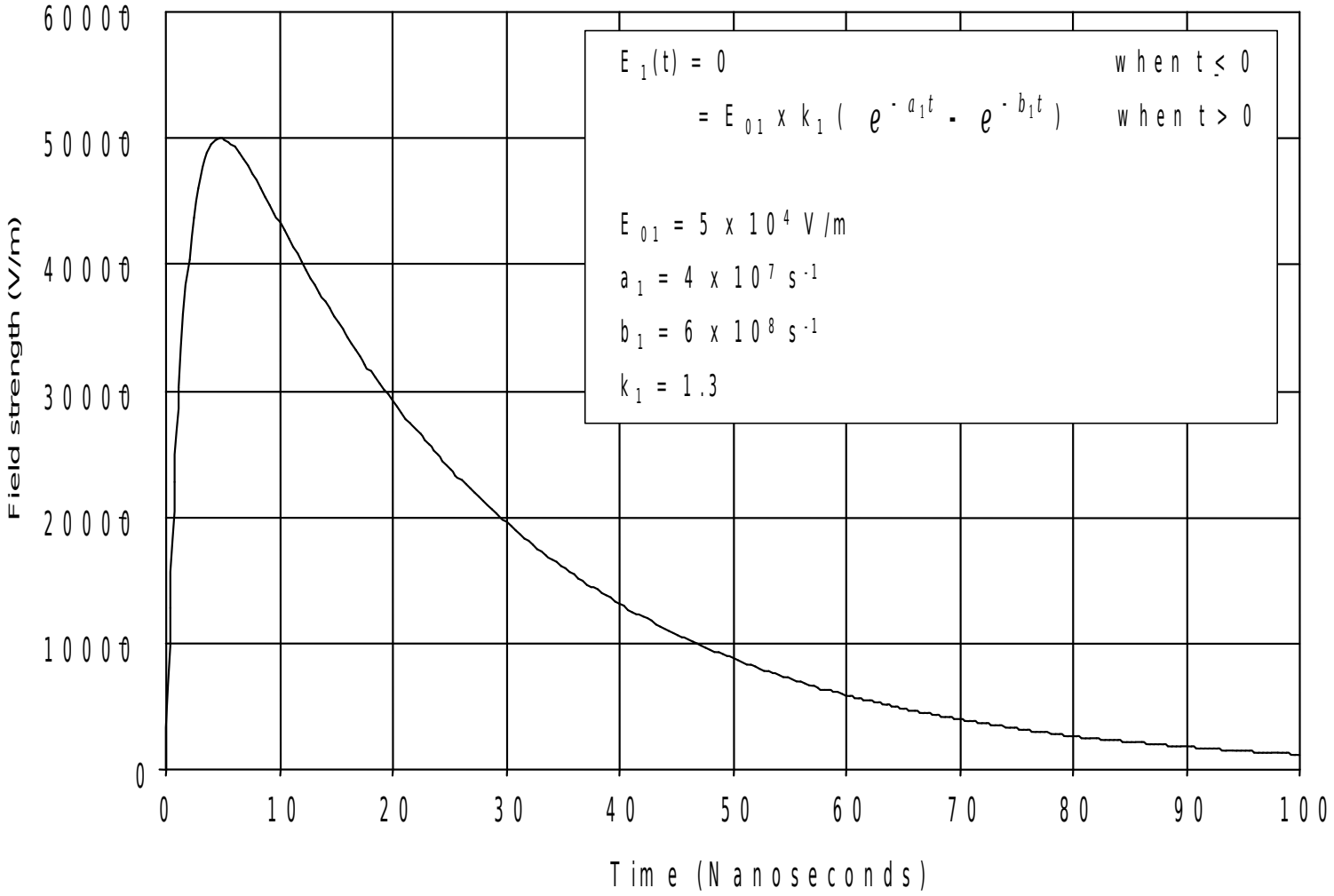
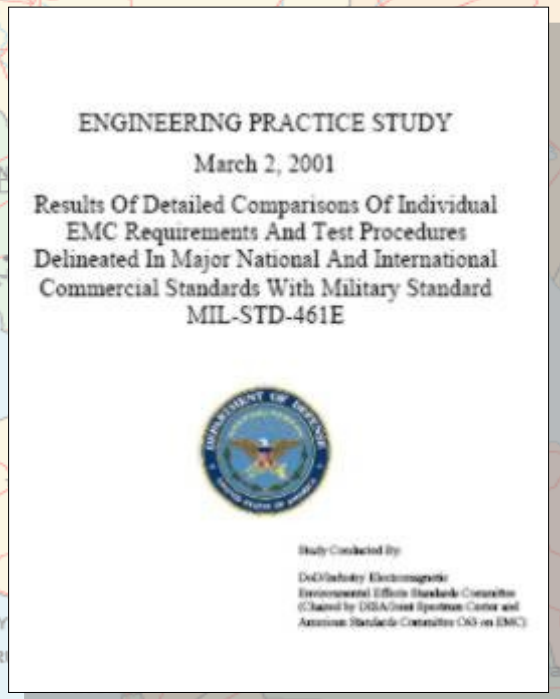


Figure RS105-1. RS105 Limit For All Applications



Commercial and Other E3 Standards

- **American National Standards Institute (ANSI), Institute of Electrical and Electronics Engineers (IEEE), Society of Automotive Engineers (SAE)**
- **Federal Communications Commission (FCC)**
- **Radio Technical Commission for Aeronautics (RTCA) DO-160D**
- **International**
  - **European Union (EU)**
  - **International Electro-technical Commission (IEC)**
  - **International Special Committee on Radio Interference (CISPR)**
  - **Comité Européen de Normalisation Électrotechnique (European Committee for Electrotechnical Standardization) (CENELEC)**
  - **North Atlantic Treaty Organization (NATO)**
- **EPS 0178 -** *Results Of Detailed Comparisons Of Individual EMC Requirements And Test Procedures Delineated In Major National And International Commercial Standards With Military Standard MIL-STD-461E*
- Appendix E - MIL-HDBK-237



ENGINEERING PRACTICE STUDY

March 2, 2001

Results Of Detailed Comparisons Of Individual EMC Requirements And Test Procedures Delineated In Major National And International Commercial Standards With Military Standard MIL-STD-461E

DIFFERENCES BETWEEN COMMERCIAL AND MILITARY STANDARDS

- Major differences:
  - Unique platform requirements because of critical dependence on the reception of certain frequencies
  - More severe military RE limits due to:
    - larger concentration high-power emitters
    - more sensitive receivers in military platforms
  - The military imposes higher susceptibility (immunity) requirements due to co-located intentional emitters

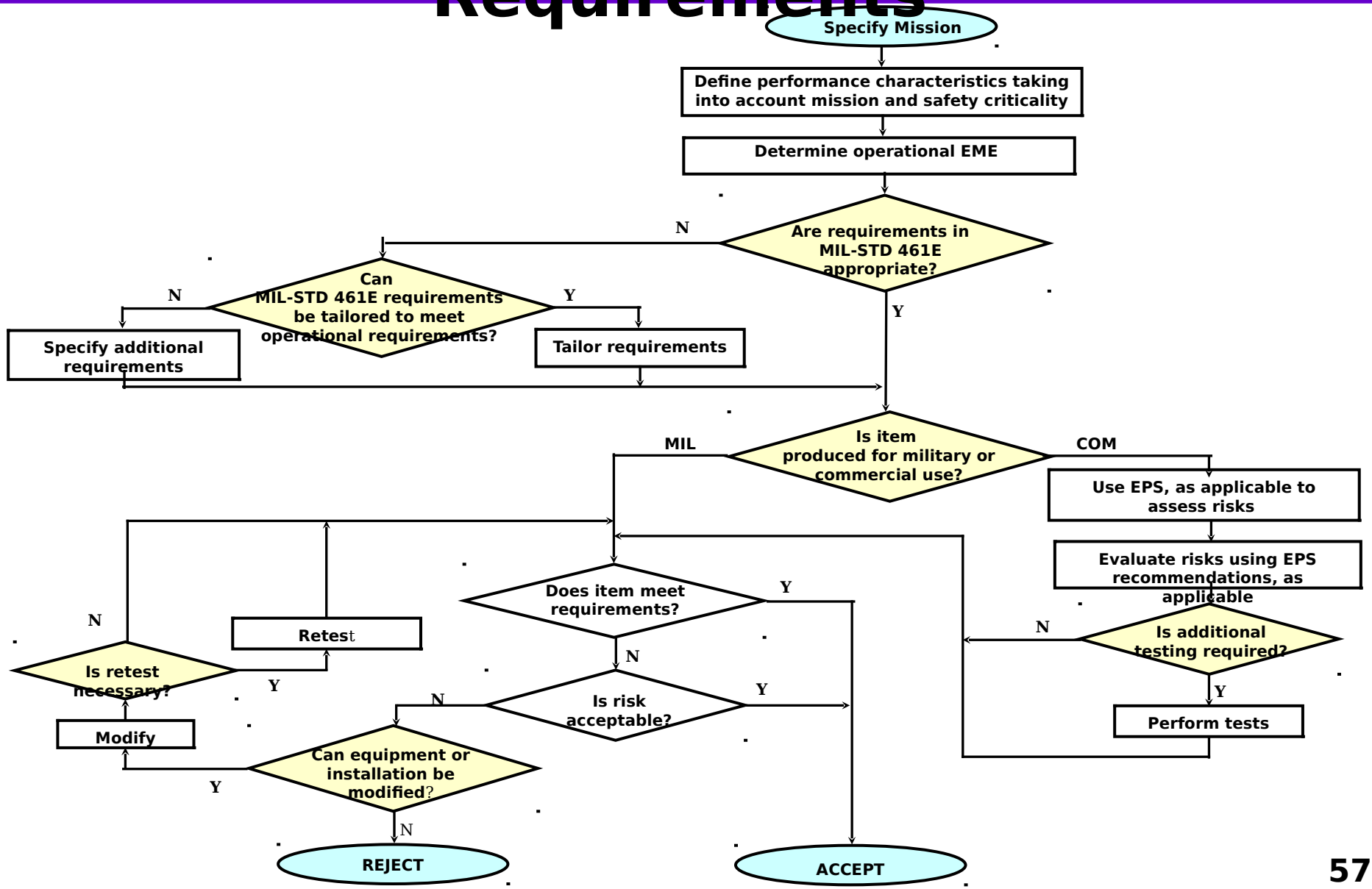
DIFFERENCES BETWEEN COMMERCIAL AND MILITARY STANDARDS

- Major differences **(continued)**
  - Military platforms have grounded conducting surfaces for mounting equipment; civilian items are usually mounted on ungrounded tables
  - Military's frequency ranges are more extensive than commercial
- No commercial standard equivalent to MIL-STD-461E

Differences Between Commercial And Military Standards

- Evaluate anticipated EME vs. characteristics of the CI under consideration
- Determine:
  - Which commercial standards apply to CI?
  - Their adequacy for the intended use
  - If additional tests and requirements should be imposed
- Decision process illustrated in Figure E-1 (pg 167 of notes)

Defining Applicable EMI Requirements



NOT MEASUREMENT SENSITIVE

MIL-STD-464A
19 December 2002

SUPERSEDING
MIL-STD-464
18 March 1997

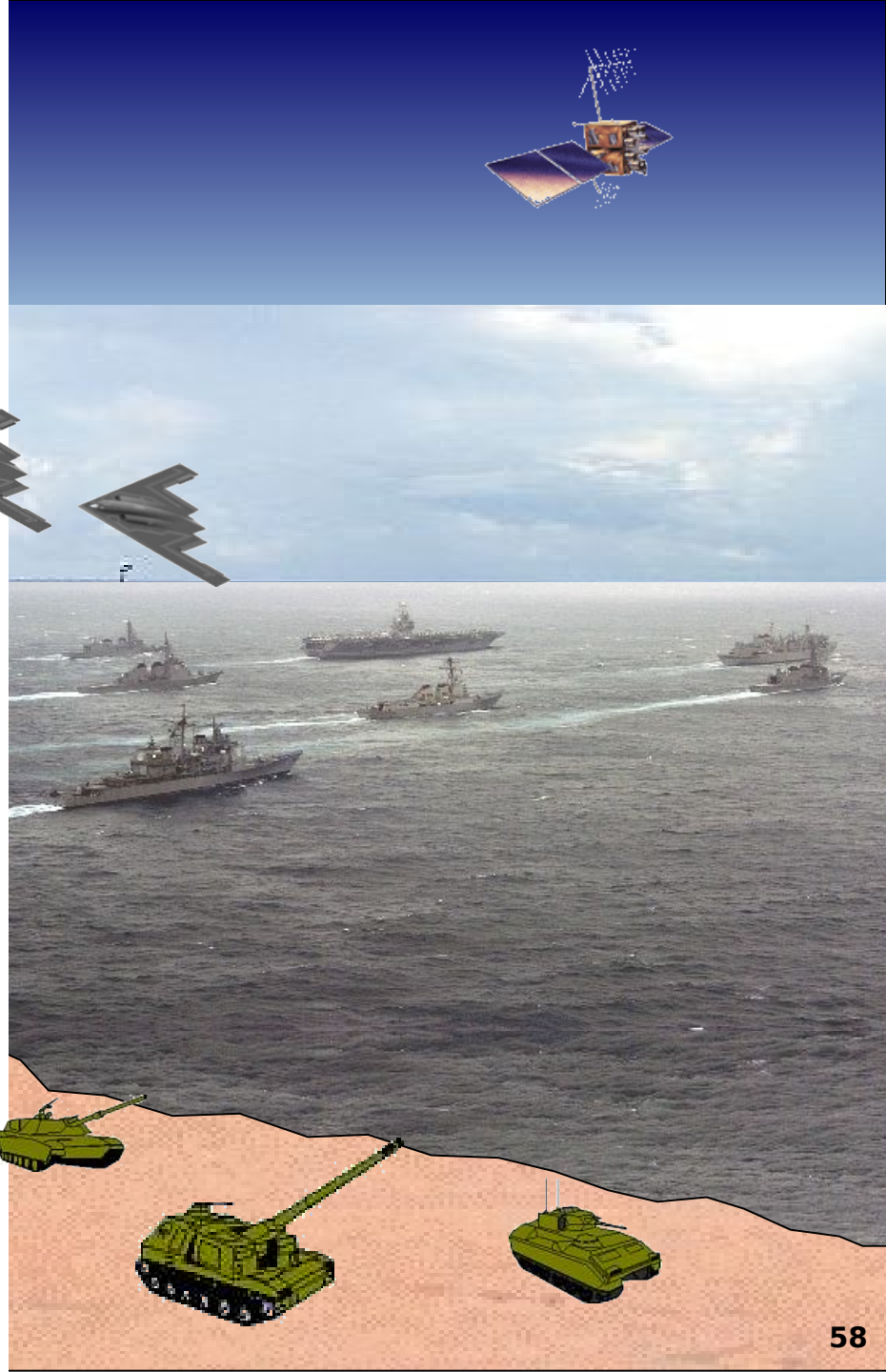
DEPARTMENT OF DEFENSE INTERFACE STANDARD

ELECTROMAGNETIC ENVIRONMENTAL EFFECTS

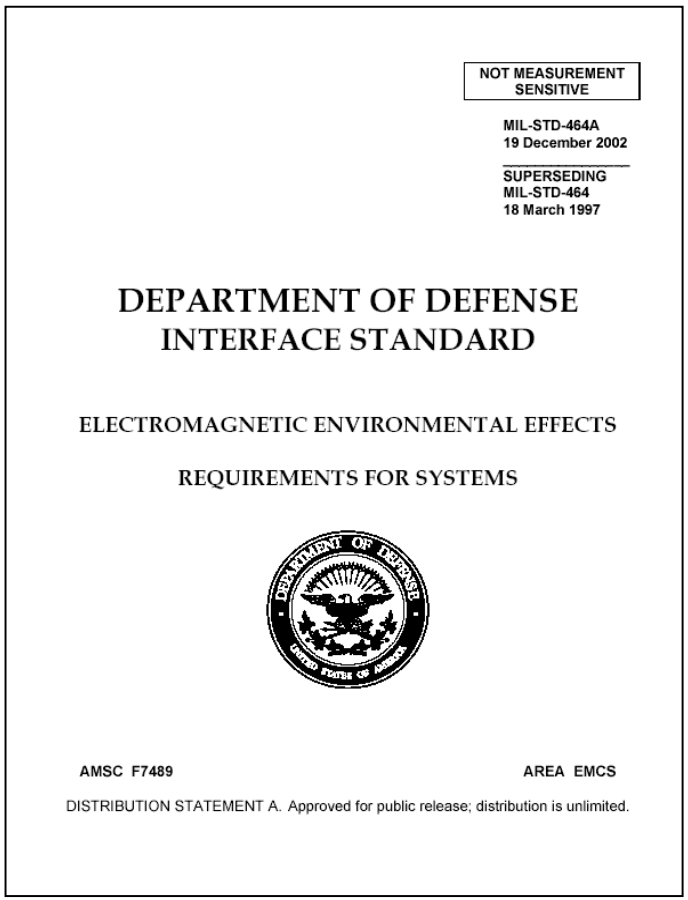
REQUIREMENTS FOR SYSTEMS

AMSC F7489 AREA EMCS

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.



MIL-STD-464A



NOT MEASUREMENT SENSITIVE

MIL-STD-464A
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DEPARTMENT OF DEFENSE
INTERFACE STANDARD

ELECTROMAGNETIC ENVIRONMENTAL EFFECTS

REQUIREMENTS FOR SYSTEMS

AMSC F7489 AREA EMCS

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Recognizes the impact of EME on the warfighting capability of the Armed Forces.

Establishes requirements on how system need to interface with each other in the EME.

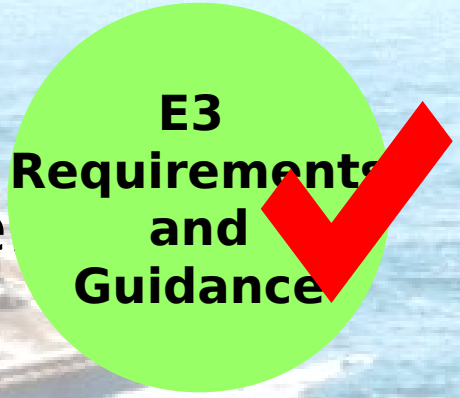
Provides Detailed requirements for:

- Intra-system EMC
- External RF EME
- Lightning
- Electromagnetic Pulse (EMP)
- Subsystems & equipment EMI
- Electrostatic charge control
- Electromagnetic radiation hazard
- Life cycle, E3 hardness
- Electrical bonding
- Electrical grounds
- TEMPEST
- Emission control
- EM spectrum compatibility

MIL-STD-464A

What it provides:

Basic E3 requirements and guidance



What it doesn't provide:

Go/No Go or Pass/Fail test procedures.

A standard to establish requirements on how systems need to interface with each other in the Electromagnetic Environmental Effects (E3) arena

MIL-STD-464A Format

MAIN BODY

(Specifies a base line set of requirements)

- ☑ **Definitions**
- ☑ **General Requirements**
- ☑ **Detailed Requirements**
- ☑ **Data Item Descriptions**

APPENDIX

- ☑ **Requirements (***repeats standard in italics***)**
  - **Rationale**
  - **Guidance**
  - **Lessons Learned**
- ☑ **Verification**
  - **Rationale**
  - **Guidance**
  - **Lessons Learned**

MIL-STD-464A Contents

Detailed Requirement			Appendix	
Subject	**Para.**	**Page**	**Para.**	**Page**
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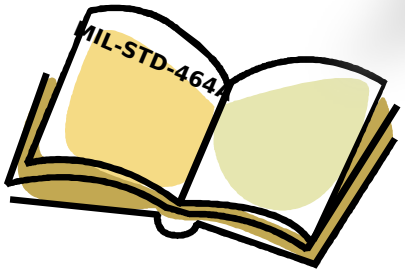
Intra-system EMC	5.2	5	A5.2	36
External RF EME	5.3	6	A5.3	44
Lightning	5.4	9	A5.4	54
Electromagnetic Pulse (EMP)	5.5	9	A5.5	60
Subsystems & equipment EMI	5.6	9	A5.6	65
Electrostatic charge control	5.7	11	A5.7	72
Electromagnetic radiation hazard	5.8	11	A5.8	79
Life cycle, E3 hardness	5.9	13	A5.9	86
Electrical bonding	5.10	13	A5.10	91
Electrical grounds	5.11	14	A5.11	101
TEMPEST	5.12	14	A5.12	106
Emission control	5.13	14	A5.13	107
EM spectrum compatibility	5.14	15	A5.14	110

MIL-STD-464A Contents

Each section has overall requirements similar to the one below for Intra-System EMC

5.2 Intra-System Electromagnetic Compatibility (EMC)

The system shall be electromagnetically compatible within itself such that system operational performance requirements are met. Compliance shall be verified by system-level test, analysis, or a combination thereof.



EMC Requirements

EMP

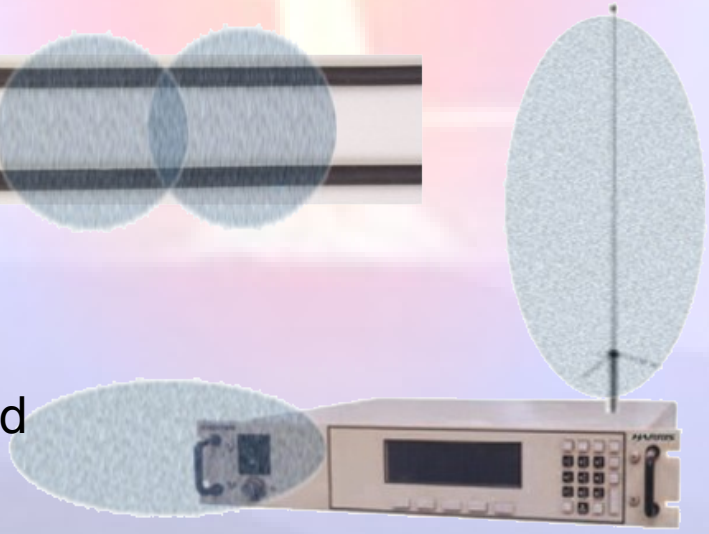
Lightning

External RF EME

External to System

EME issues

Cross coupling of electrical currents



Self-generated RF transmissions from antennas

Unintentional conducted and radiated EM emissions

Internal to System

EMC Requirements (cont.)

In addition to design requirements, MIL-STD-464A provides verification requirements

Costly Delays during system development

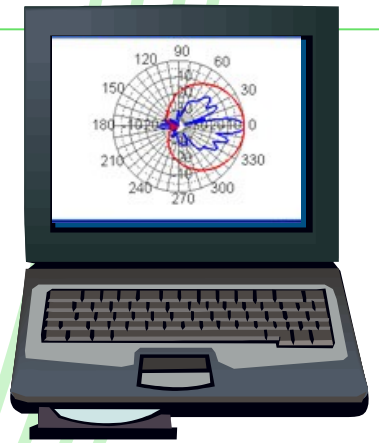
Mission Aborts

Reduced system and equipment operational effectiveness

Identify assets for E3 requirement verification early!

5.2 Intra-System EMC

The most basic element of demonstrating that E3 design efforts have been successful is verification of intra-system EMC through testing, supported by analysis.

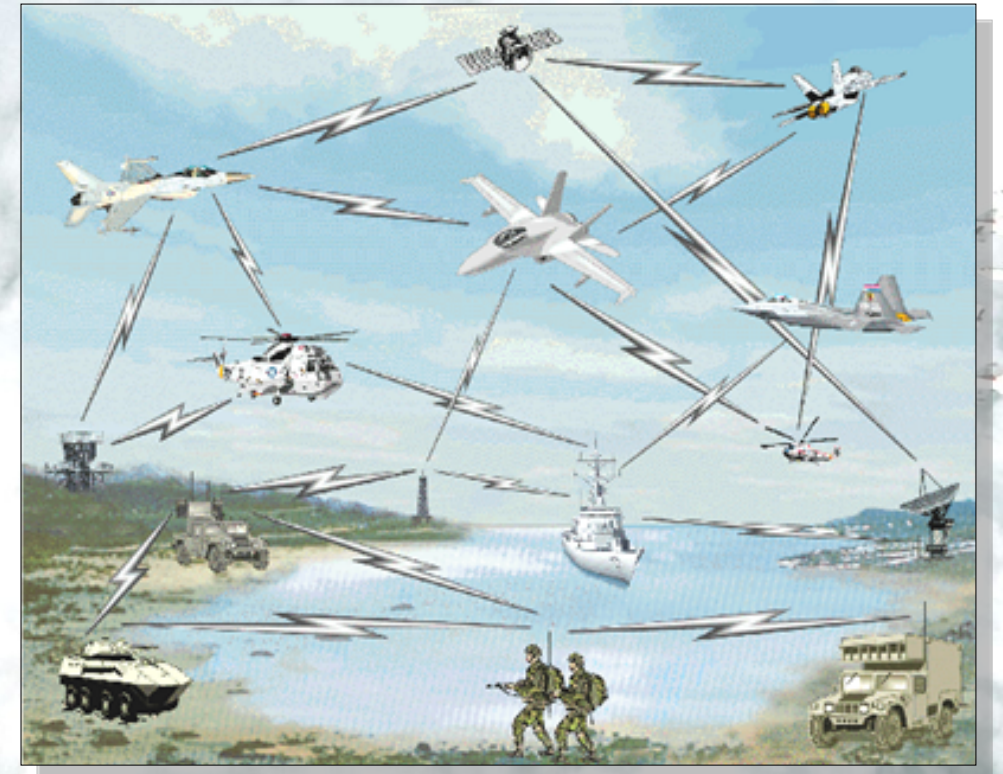


EMC Testing

EMC Analysis

5.3 External RF EME

The system shall be electromagnetically compatible with its defined external RF EME such that its SOP requirements are met.



5.3 External RF EME (cont.)

TABLE 1A. External EME for deck operations on ships

Frequency Range (MHz)	Flight Deck		Weather Deck	
	Electric Field (V/m – rms)		Electric Field (V/m – rms)	
	Peak	Average	Peak	Average
0.01 - 2	45	45	-	-
2 - 30	100	100	200	200
30 - 150	61	61	61	61
150 - 225	61	61	61	61
225 - 400	61	61	61	61
400 - 700	151	71	151	71
700 - 790	162	95	162	95
790 - 1000	1125	99	1125	99
1000 - 2000	550	112	550	180
2000 - 2700	184	158	184	158
2700 - 3600	2030	184	2030	184
3600 - 4000	290	200	290	200
4000 - 5400	290	200	290	200

TABLE 1B. External EME for shipboard operations in the main beam of transmitters

Frequency Range (MHz)	Electric Field (V/m - rms)	
	Peak	Average
0.01 - 2	-	-
2 - 30	200	200
30 - 150	20	20
150 - 225	10	10
225 - 400	25	25
400 - 700	1940	260
700 - 790	15	15
790 - 1000	2160	410
1000 - 2000	2600	460
2000 - 2700	6	6
2700 - 3600	27460	2620
3600 - 4000	9710	310
4000 - 5400	160	160
5400 - 5900	3500	160
5900 - 6000	310	310

5.3 External RF EME (cont.)

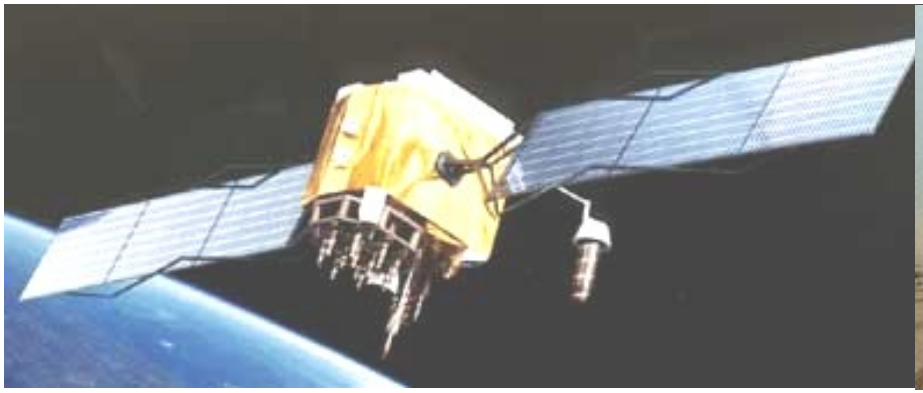


TABLE 1C. External EME for space and launch vehicle systems

Frequency Range (MHz)	Electric Field (V/m - rms)	
	Peak	Average
0.01 - 100	20	20
100 - 1000	100	100
1000 - 10000	200	200
10000 - 40000	20	20
40000 - 45000	-	-

TABLE 1D. External EME for ground systems

Frequency Range (MHz)	Electric Field (V/m - rms)	
	Peak	Average
0.01 - 2	25	25
2 - 250	50	50
250 - 1000	1500	50
1000 - 10000	2500	50
10000 - 40000	1500	50
40000 - 45000	-	-

5.3 External RF EME (cont.)

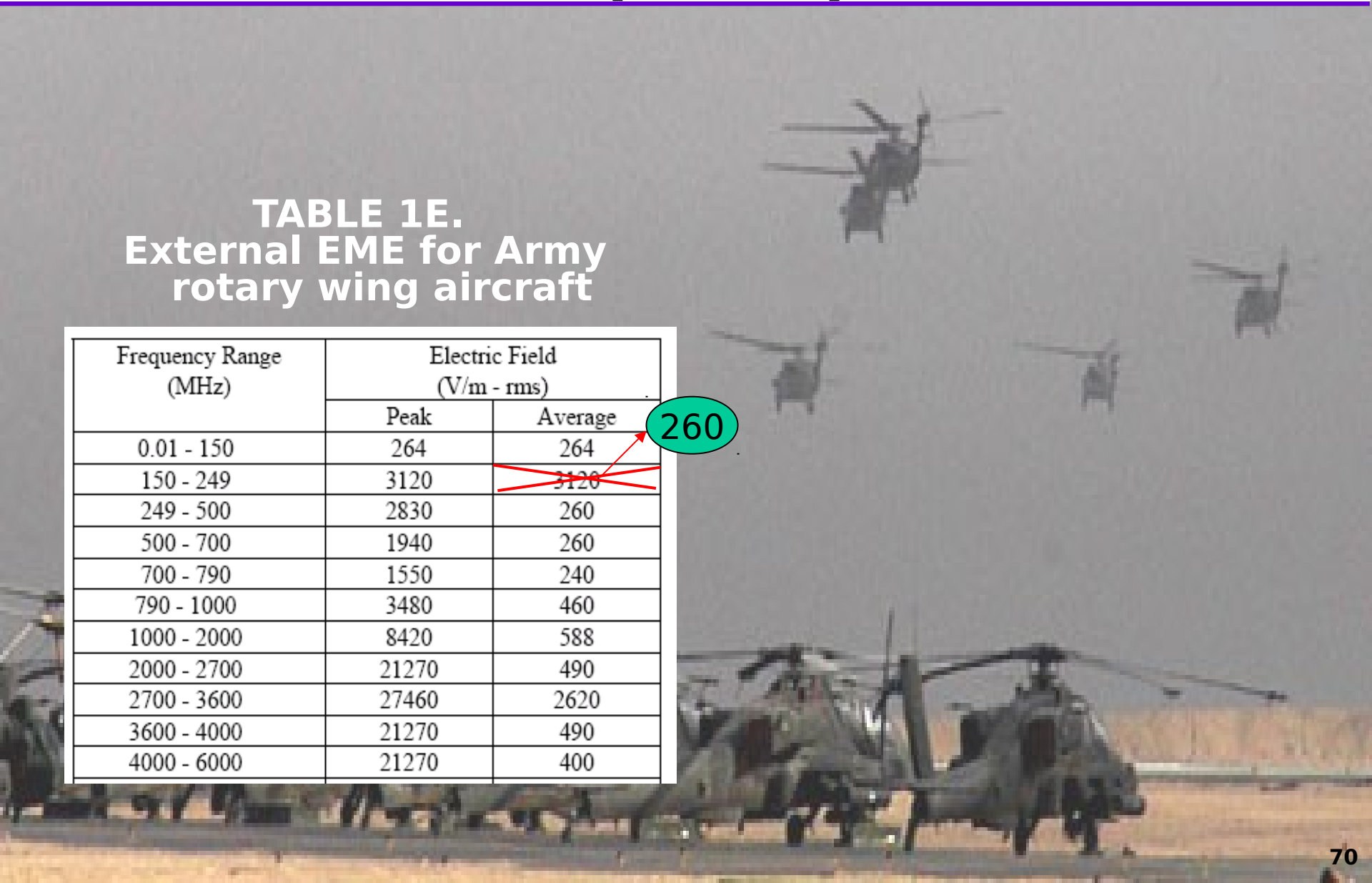


TABLE 1E.
External EME for Army rotary wing aircraft

Frequency Range (MHz)	Electric Field (V/m - rms)	
	Peak	Average
0.01 - 150	264	264
150 - 249	3120	~~3120~~ 260
249 - 500	2830	260
500 - 700	1940	260
700 - 790	1550	240
790 - 1000	3480	460
1000 - 2000	8420	588
2000 - 2700	21270	490
2700 - 3600	27460	2620
3600 - 4000	21270	490
4000 - 6000	21270	400

260

5.3 External RF EME (cont.)

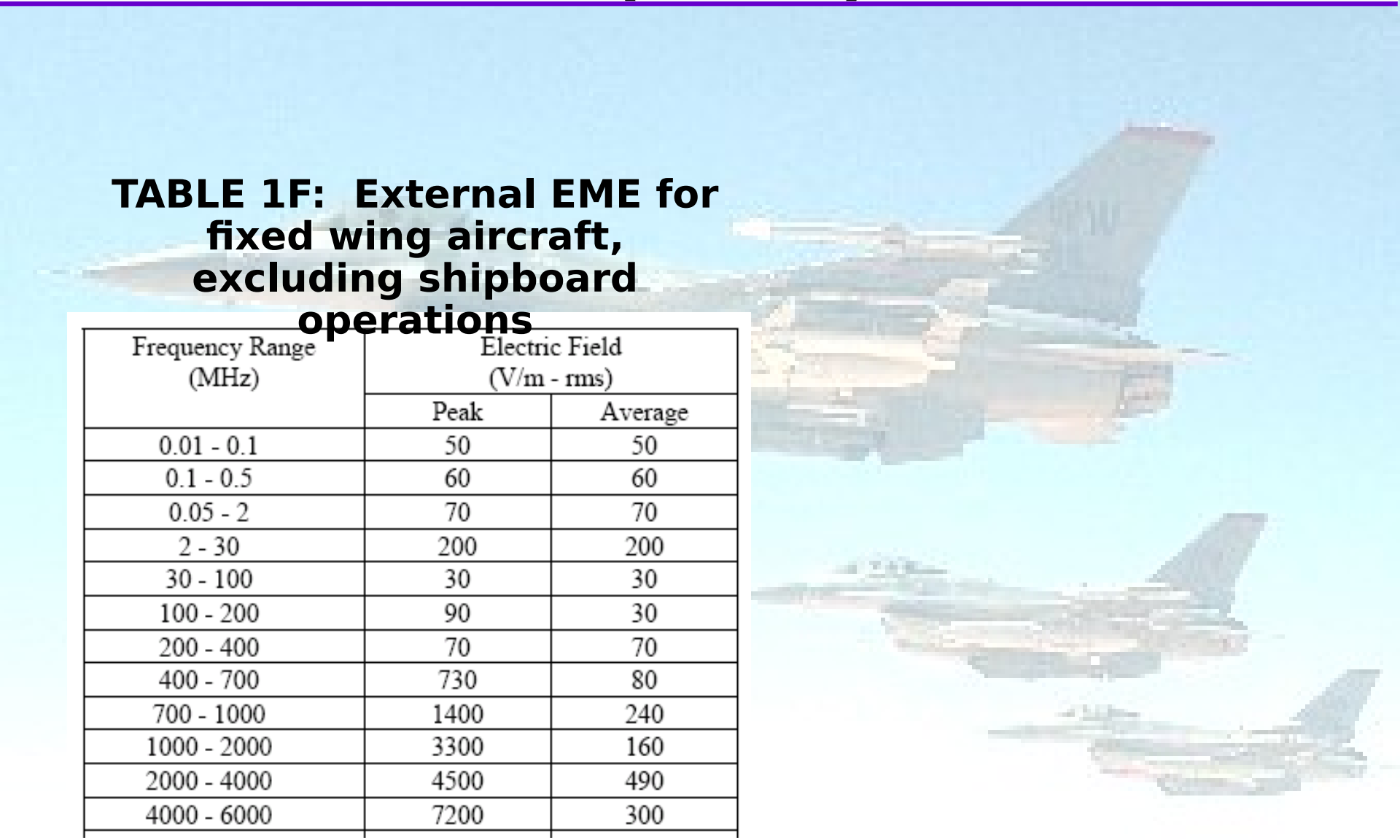


TABLE 1F: External EME for fixed wing aircraft, excluding shipboard operations

Frequency Range (MHz)	Electric Field (V/m - rms)	
	Peak	Average
0.01 - 0.1	50	50
0.1 - 0.5	60	60
0.05 - 2	70	70
2 - 30	200	200
30 - 100	30	30
100 - 200	90	30
200 - 400	70	70
400 - 700	730	80
700 - 1000	1400	240
1000 - 2000	3300	160
2000 - 4000	4500	490
4000 - 6000	7200	300

5.4 Lightning

- The system shall meet its operational performance requirements for both direct and indirect effects of lightning
- Ordnance shall meet its operational performance requirements after experiencing a near strike in an exposed condition and a direct strike in a stored condition.
- Ordnance shall remain safe during and after experiencing a direct strike in an exposed condition

5.4 Lightning (cont.)

Direct effects of lightning are:

- Burning
- Eroding
- Blasting
- Structural deformation
- High pressure shock waves
- Magnetic forces produced by the associated high currents

Indirect effects are those resulting from the electromagnetic fields associated with lightning and the interaction of these electromagnetic fields with equipment in the system.

5.5 Electromagnetic Pulse (EMP)

The system shall meet its operational performance requirements after being subjected to the EMP Environment.

5.5 Electromagnetic Pulse (EMP)

The following are elements of an iterative process for designing and verifying protection of a system's electrical and electronic equipment against the effects of EMP.

a. EMP coupling analysis

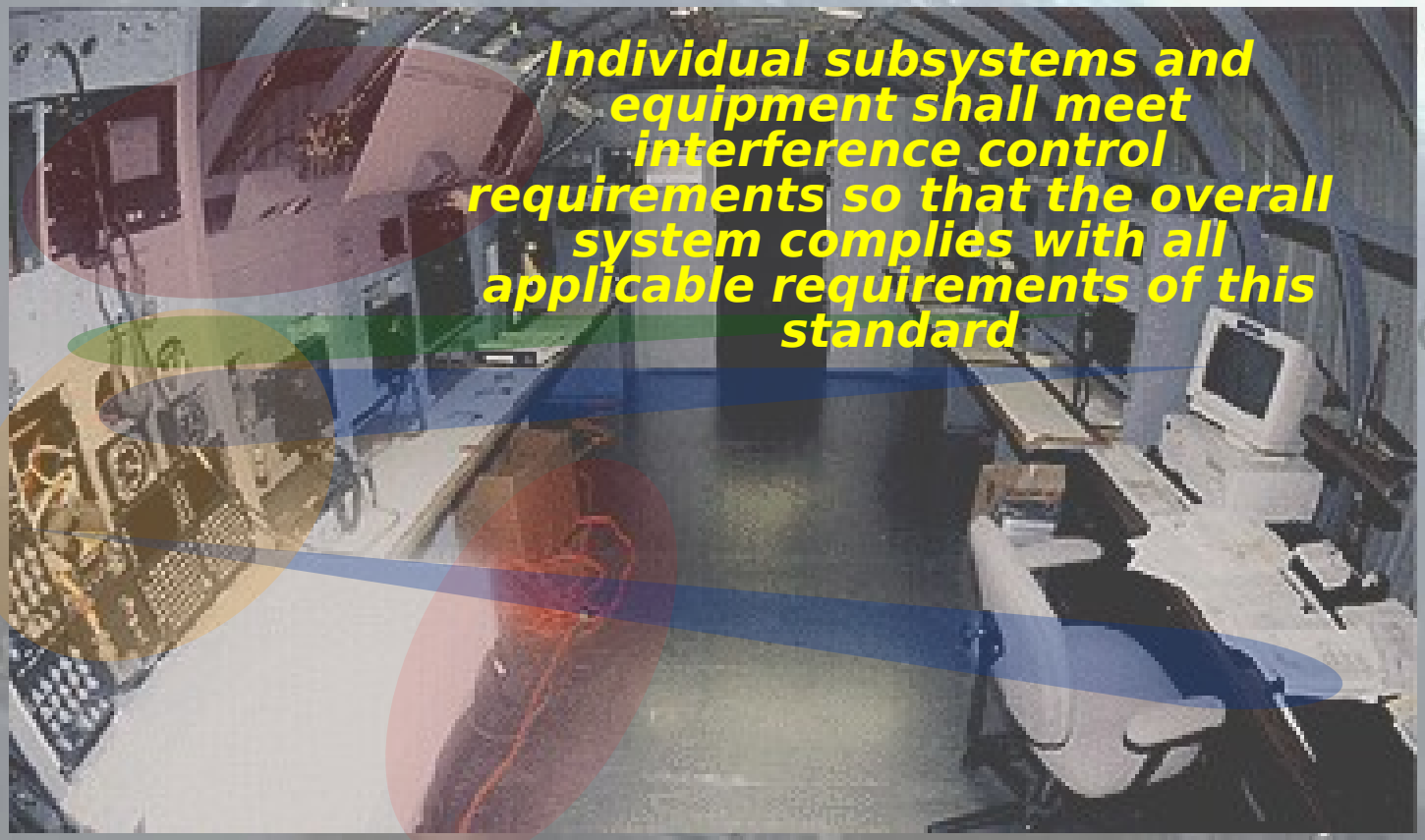
b. Identification of relevant subsystems

c. Equipment strength determination

d. Specification compliance demonstration

5.6 Subsystems and Equipment EMI

Intra-system EMC is the most basic element of E3 concerns.


Individual subsystems and equipment shall meet interference control requirements so that the overall system complies with all applicable requirements of this standard

5.6 Subsystems and Equipment EMI (cont.)

Areas of EMI requirements

Unintentional subsystem emissions

Susceptibility to external influences.

Each of these areas can have conducted and radiated controls.

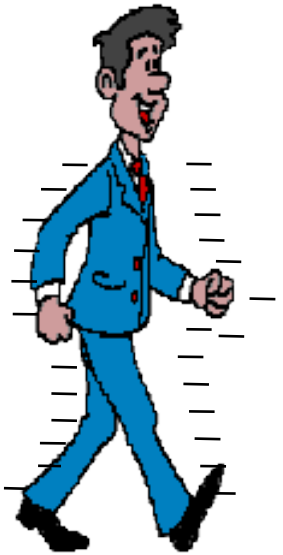
5.7 Electrostatic Charge Control

The system shall control and dissipate the build-up of electrostatic charges caused by precipitation static (p-static) effects, fluid flow, air flow, exhaust gas flow, personnel charging, charging of launch vehicles (including pre-launch conditions) and space vehicles (post deployment), and other charge generating mechanisms to avoid fuel ignition and ordnance hazards, to protect personnel from shock hazards, and to prevent performance degradation or damage to electronics.

5.7 Electrostatic Charge Control

Nature

Dust Rain Snow



System Related

Human Related

5.7.1 Vertical Lift and In-Flight Refueling

The system shall meet its operational performance requirements when subjected to a 300 kilovolt discharge. This requirement is applicable to vertical lift aircraft, in-flight refueling of any aircraft, and systems operated or transported externally by vertical lift aircraft. Compliance shall be verified by test (such as MIL-STD-331 for ordnance), analysis, inspections, or a combination thereof. The test configuration shall include electrostatic discharge in the vertical lift mode and in-flight refueling mode from a simulated aircraft capacitance of 1000 picofarad, through a maximum of one ohm resistance.

5.7.2 Precipitation Static (P-Static)

The system shall control p-static interference to antenna-connected receivers onboard the system or on the host platform such that system operational performance requirements are met. The system shall protect against puncture of structural materials and finishes and shock hazards from charge accumulation. Compliance shall be verified by test, analysis, inspections, or a combination thereof.

5.7.3 Ordnance Subsystems

Ordnance subsystems shall not be inadvertently initiated or dudded by a 25 kilovolt electrostatic discharge caused by personnel handling.

5.8 Electromagnetic Radiation Hazard (EMRADHAZ)

The system design shall protect personnel, fuels, and ordnance from hazardous effects of electromagnetic radiation.

5.8.1 Hazards of Electromagnetic Radiation to Personnel (HERP)

The system shall comply with current DoD criteria for the protection of personnel against the effect of electromagnetic radiation.

5.8.2 Hazards of Electromagnetic Radiation to Fuel (HERF)

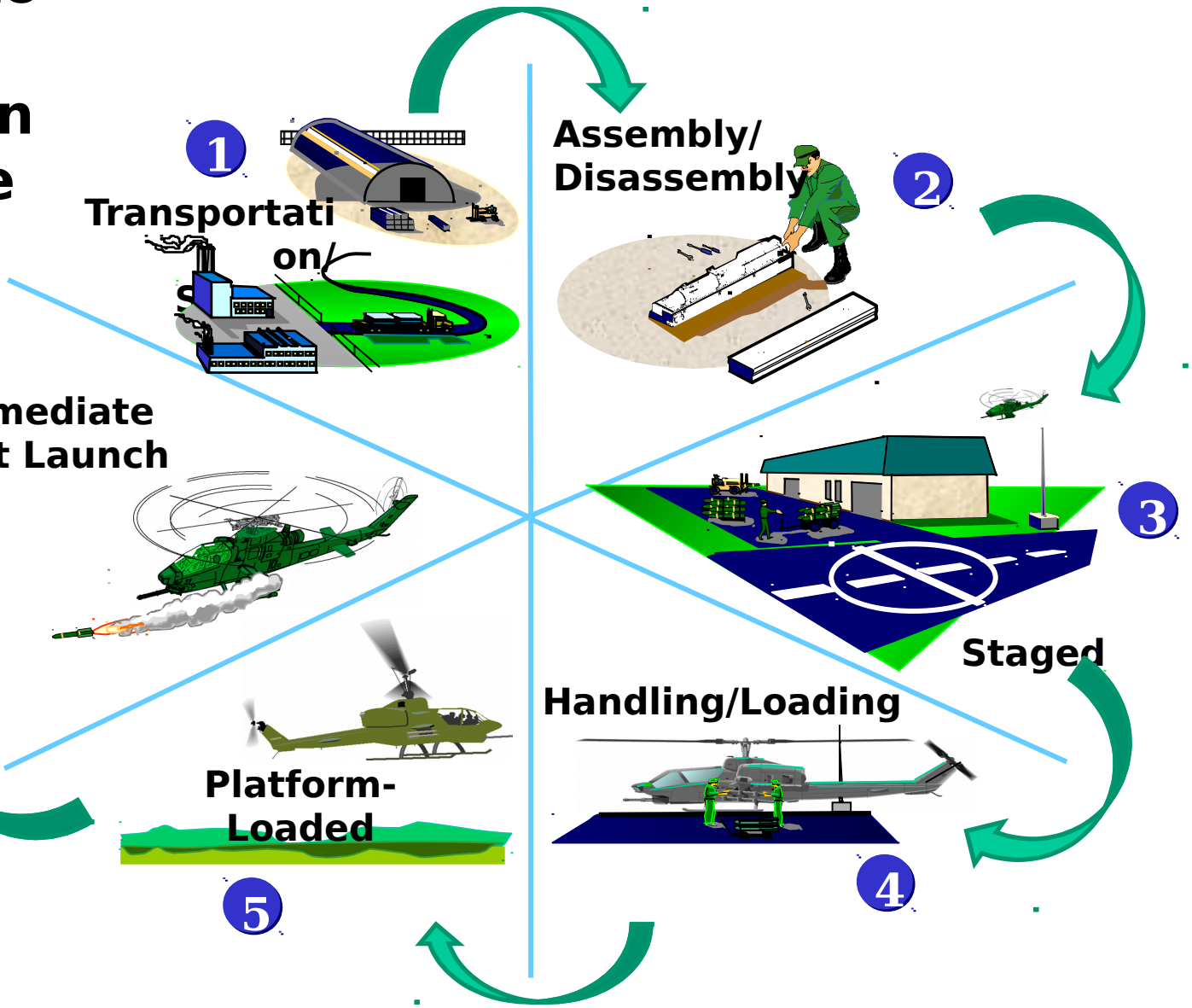
Fuels shall not be inadvertently ignited by radiated EMEs. The EME includes onboard emitters and the external EME

5.8.3 Hazards of Electromagnetic Radiation to Ordnance (HERO)

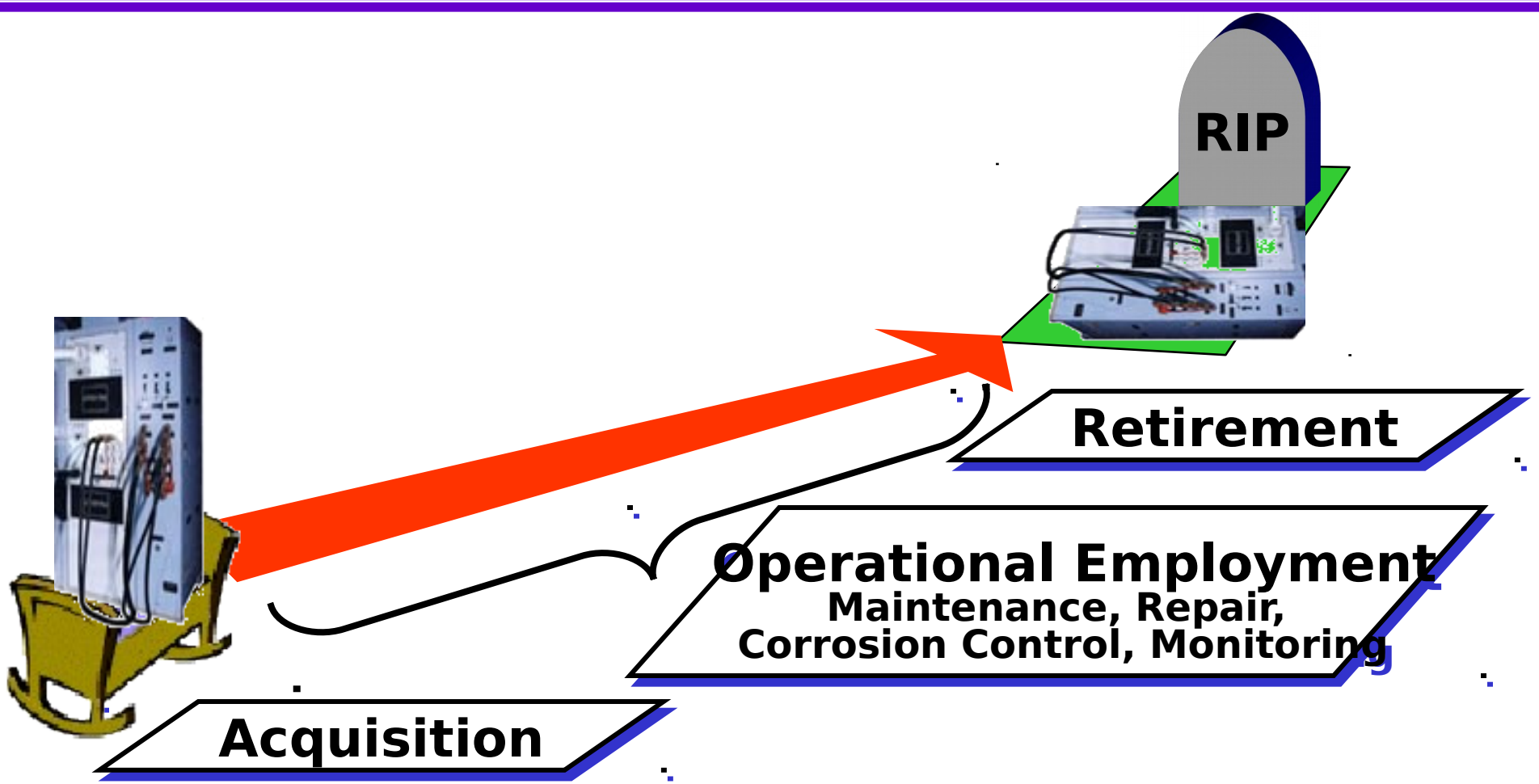
Electrically initiated devices (EIDs) in ordnance shall not be inadvertently actuated during or experience degraded performance characteristics after exposure to the external EME levels…

5.8.3 HERO: Verification Guidance

Stockpile-to-Safe Separation Sequence (S4)



5.9 Life Cycle, E3 Hardness

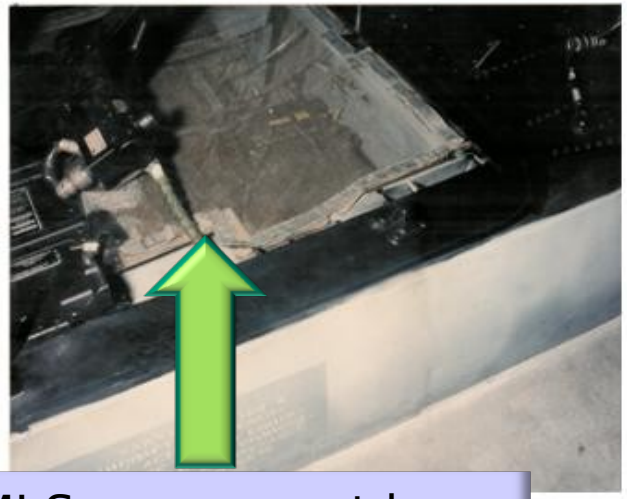


The system operational performance and E3 requirements of this standard shall be met throughout the rated life cycle of the system shall include, but not be limited to, the following: maintenance, repair, surveillance, and corrosion control.

5.9 Life Cycle, E3 Hardness (cont.)

Missing spring fingers

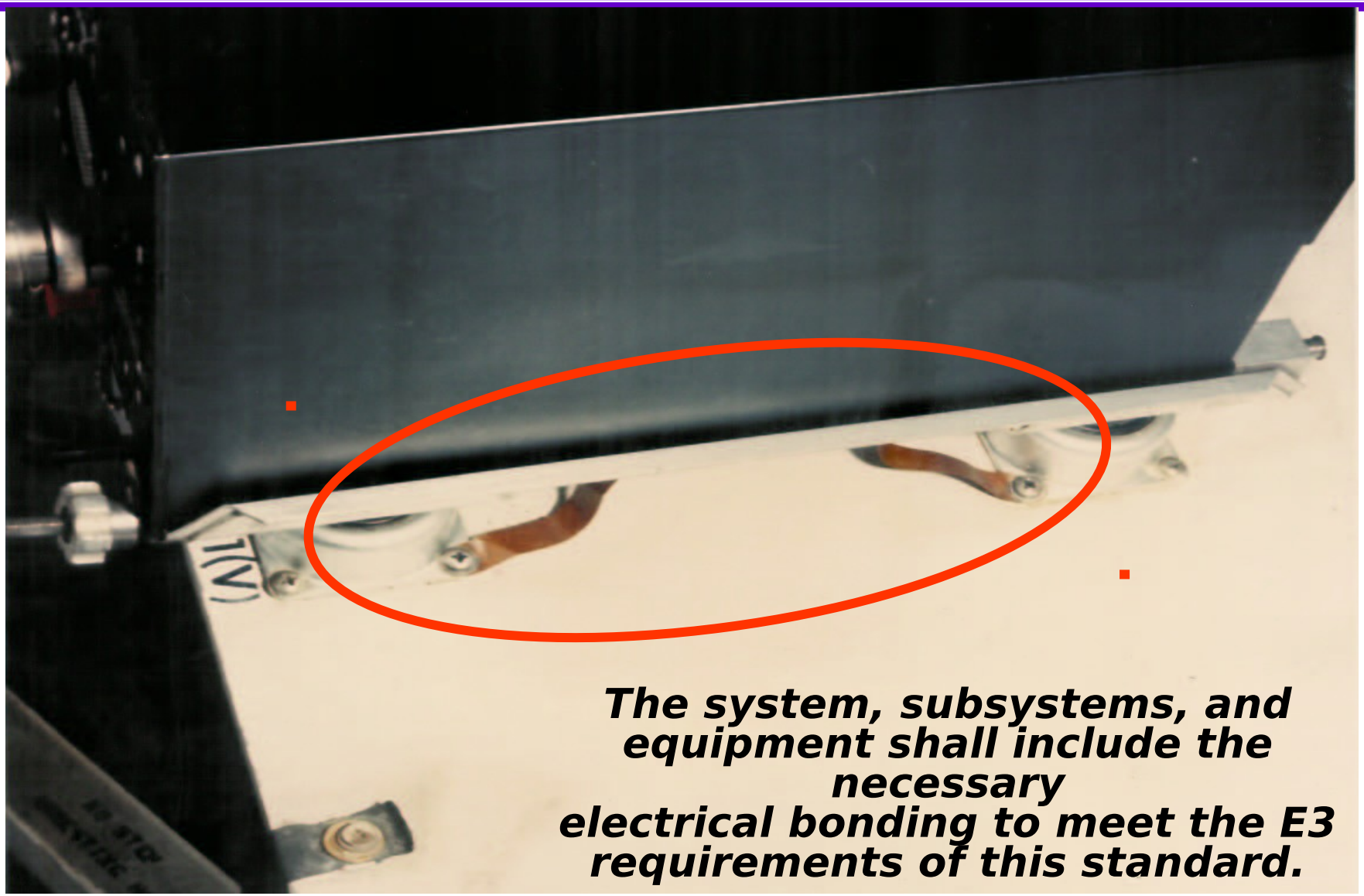
Paint over spring fingers



EMI Screens must be intact and good contact at edges.

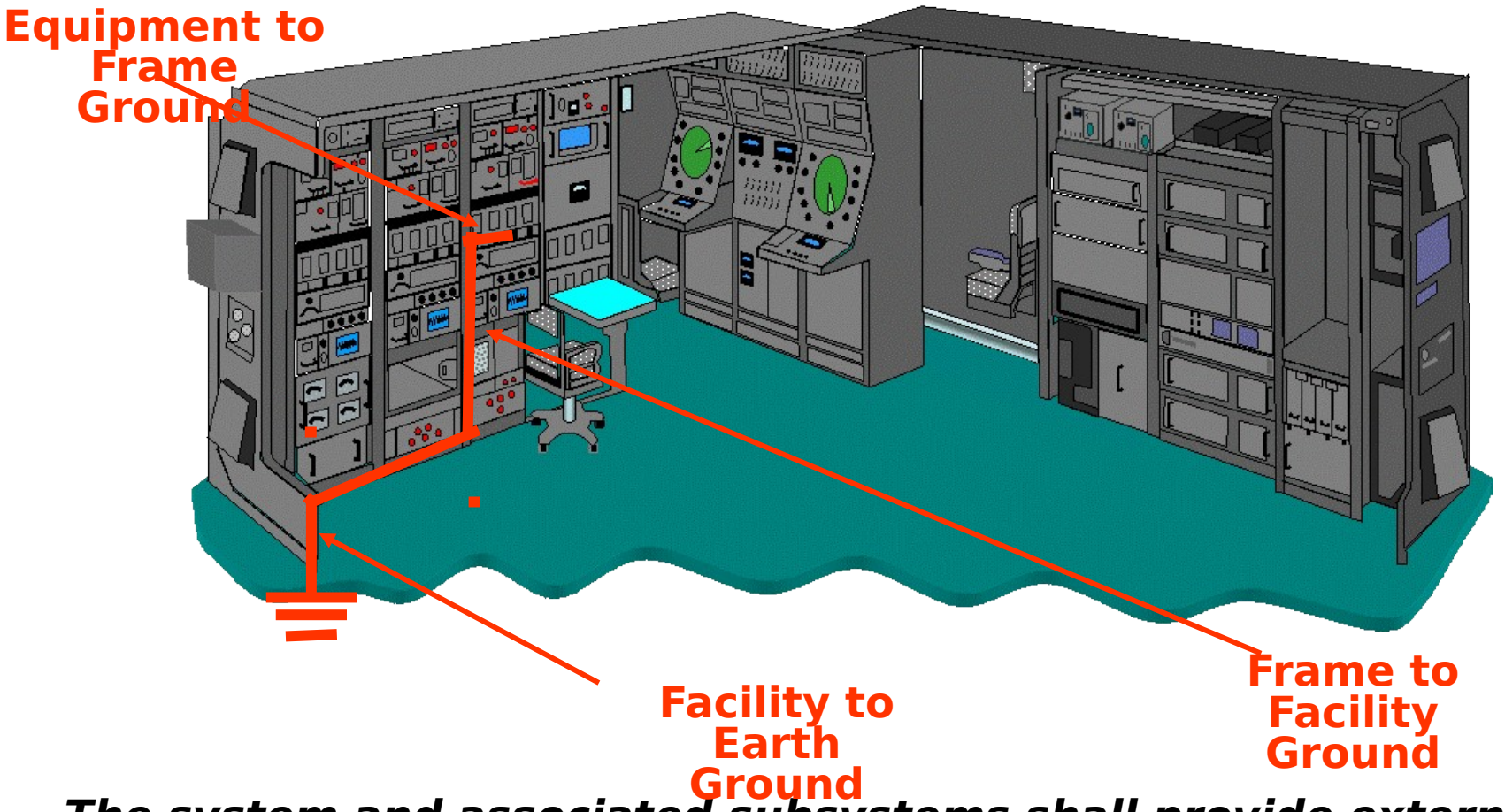
Bonding surfaces must provide conductivity.

5.10 Electrical Bonding



The system, subsystems, and equipment shall include the necessary electrical bonding to meet the E3 requirements of this standard.

5.11 External Grounds



The system and associated subsystems shall provide external grounding provisions to control electrical current flow and static charging for protection of personnel from shock, prevention of inadvertent ignition of ordnance, fuel and flammable vapors, and protection of hardware from damage.

5.12 TEMPEST

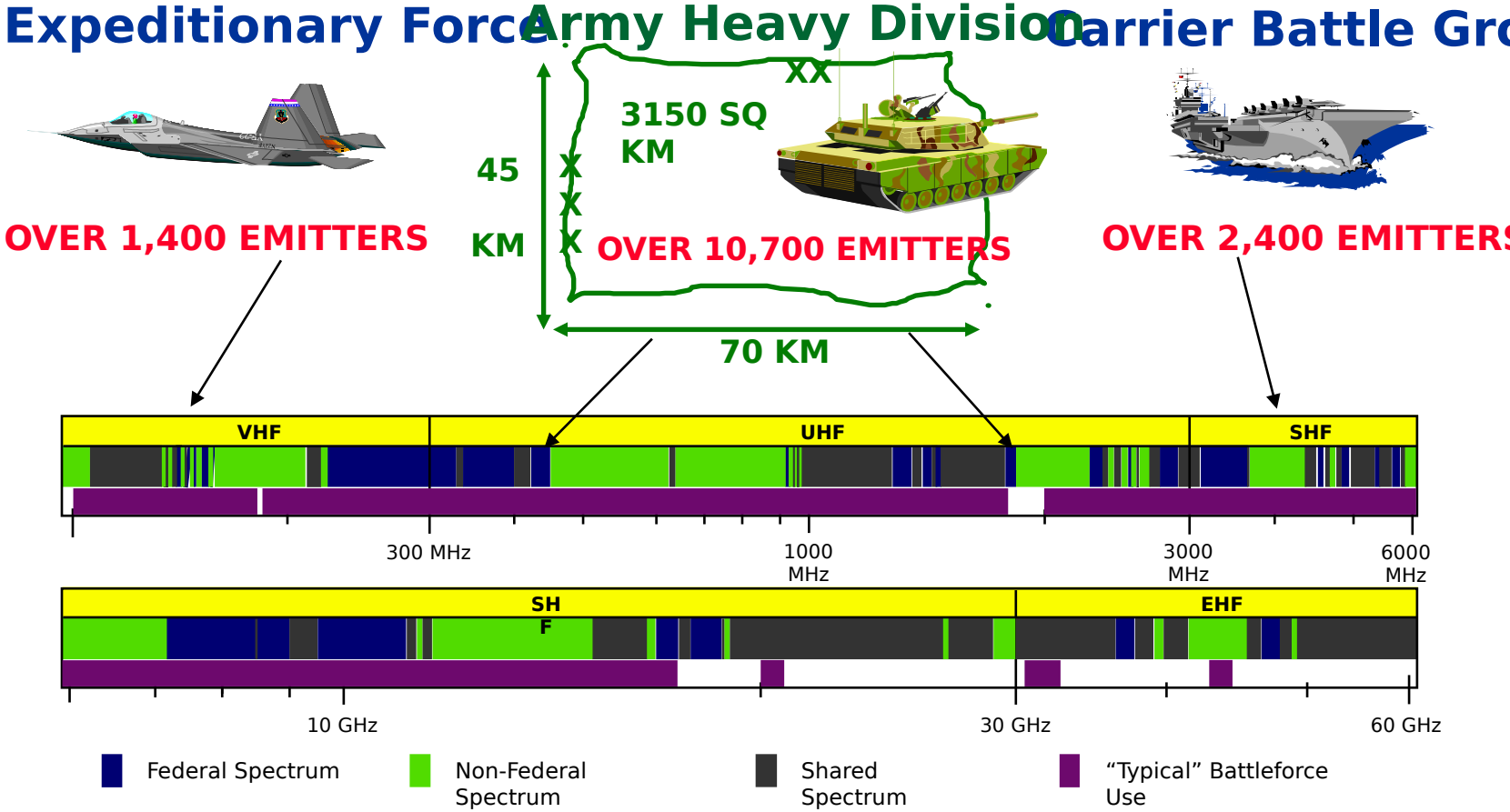
National security information shall not be compromised by emanations from classified information processing equipment.

5.13 EMCON

EMISSION CONTROL!

Unintentional electromagnetic radiated emissions shall not exceed -110 dBm/m2 at one nautical mile (-105 dBm/m2 at one kilometer) in any direction from the system over the frequency range of 500 kHz to 40 GHz, when using the resolution bandwidths listed in Table 4

5.14 EM Spectrum Compatibility



Systems, subsystems, and equipment shall comply with the DoD, national, and international regulations for the use of the electromagnetic spectrum (such as NTIA "Manual of Regulations and Procedures for Radio Frequency Management" and DoDD 4650.1).